# Modeling the risk of spread of EAB: Summer traffic is key

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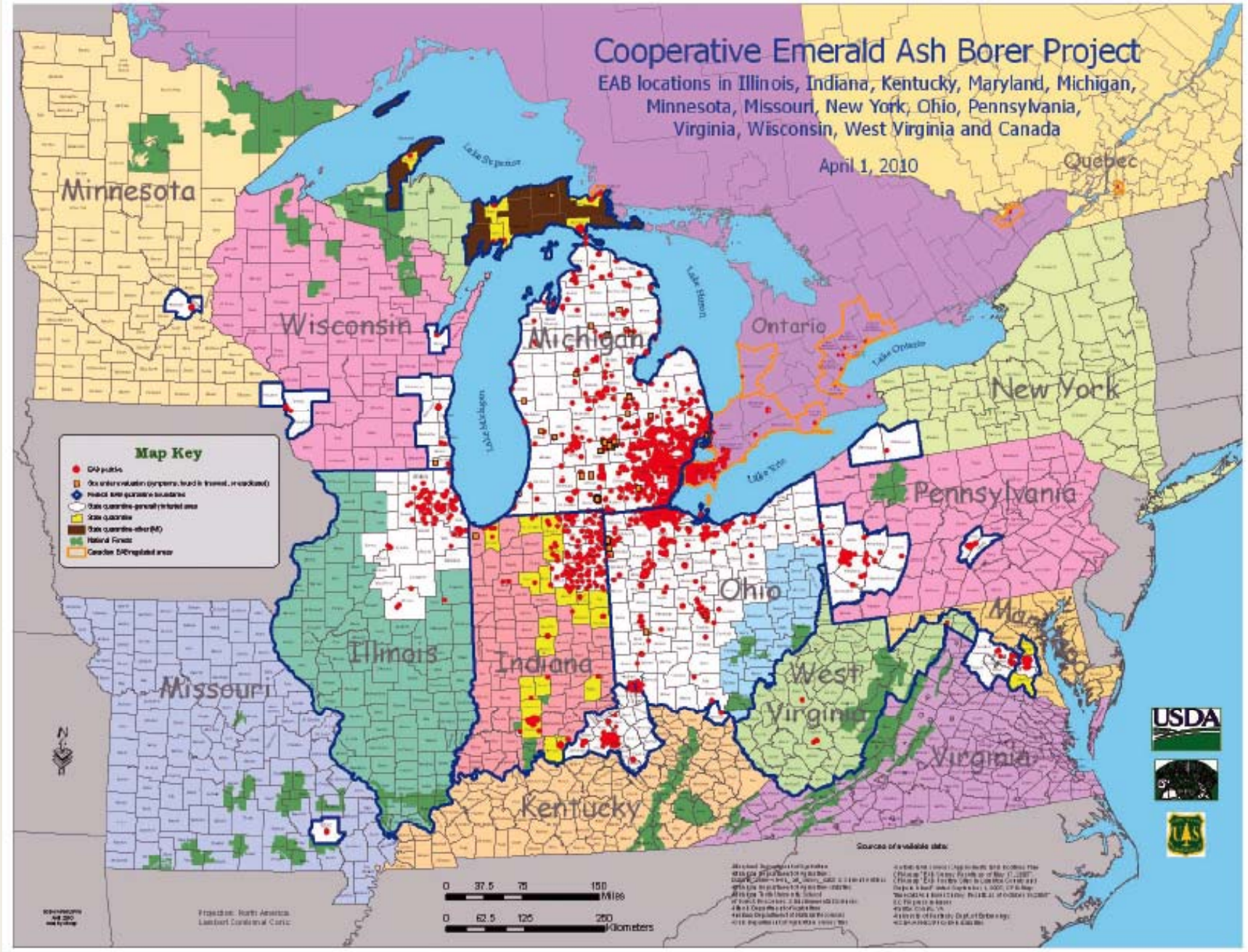
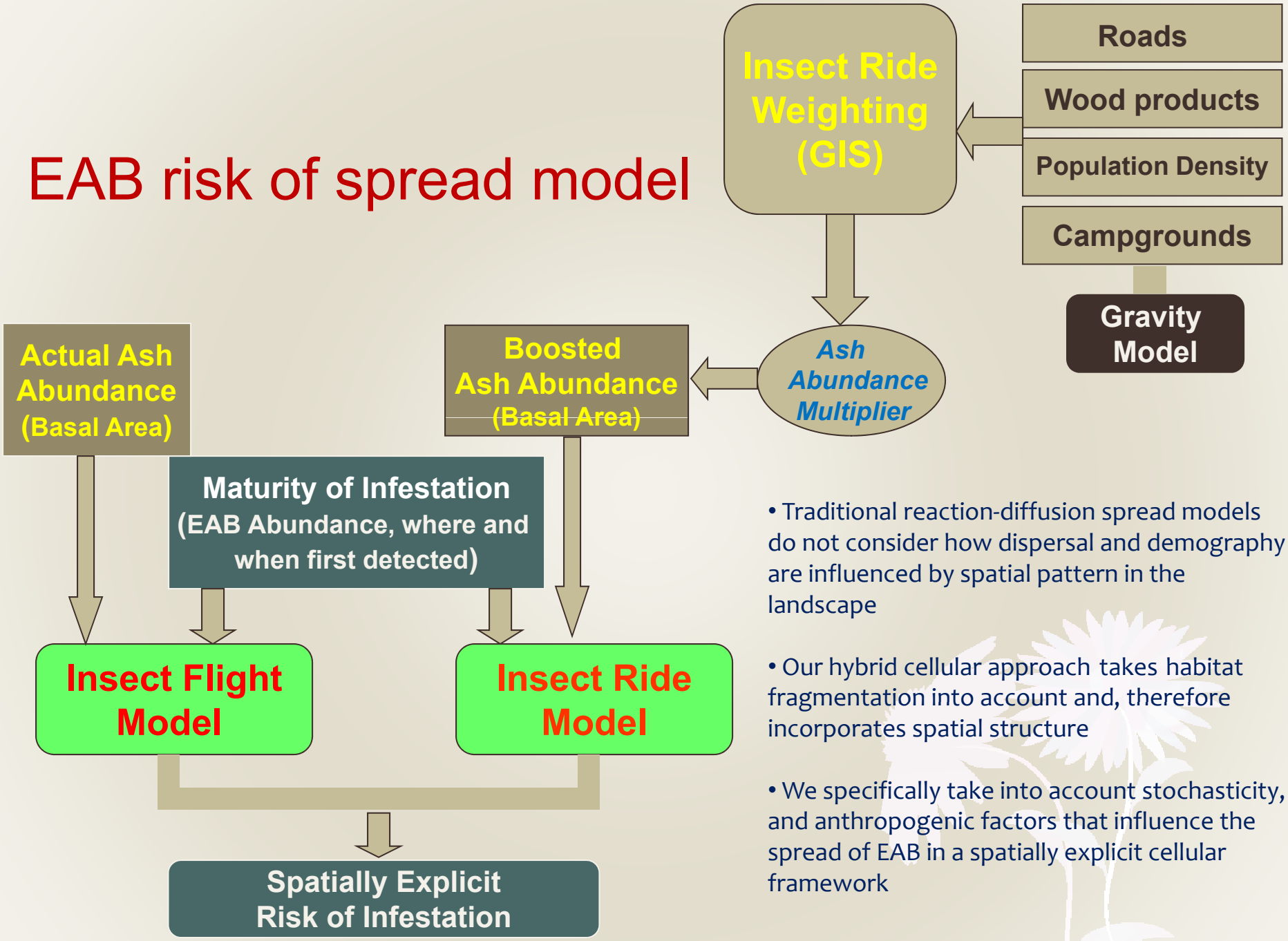
# Our Role in EAB Research

- Quantification of visual parameters on street trees to assess ash health
- Estimating ash quantity in the eastern US
- Estimating EAB abundance by year
- Modeling spread risk


Cooperative Emerald Ash Borer Project
EAB locations in Illinois, Indiana, Kentucky, Maryland, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Virginia, Wisconsin, West Virginia and Canada
April 1, 2010
Minnesota
Wisconsin
Michigan
Ontario
Quebec
New York
Pennsylvania
Ohio
Illinois
Indiana
Missouri
West Virginia
Virginia
Kentucky
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
Map Key
USDA
0 37.5 75 150 Miles
0 62.5 125 250 Kilometers

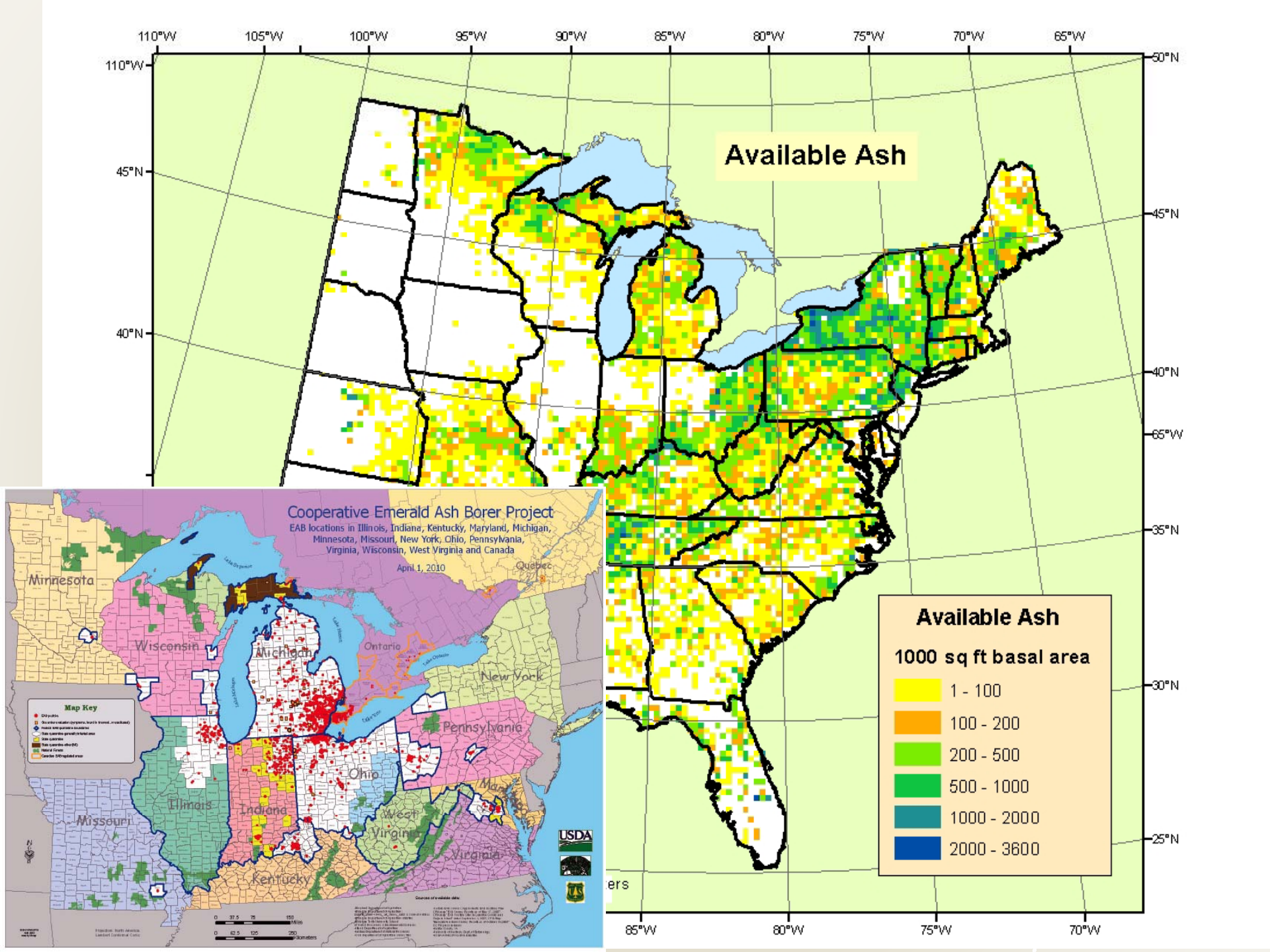
# EAB risk of spread model




- Traditional reaction-diffusion spread models do not consider how dispersal and demography are influenced by spatial pattern in the landscape

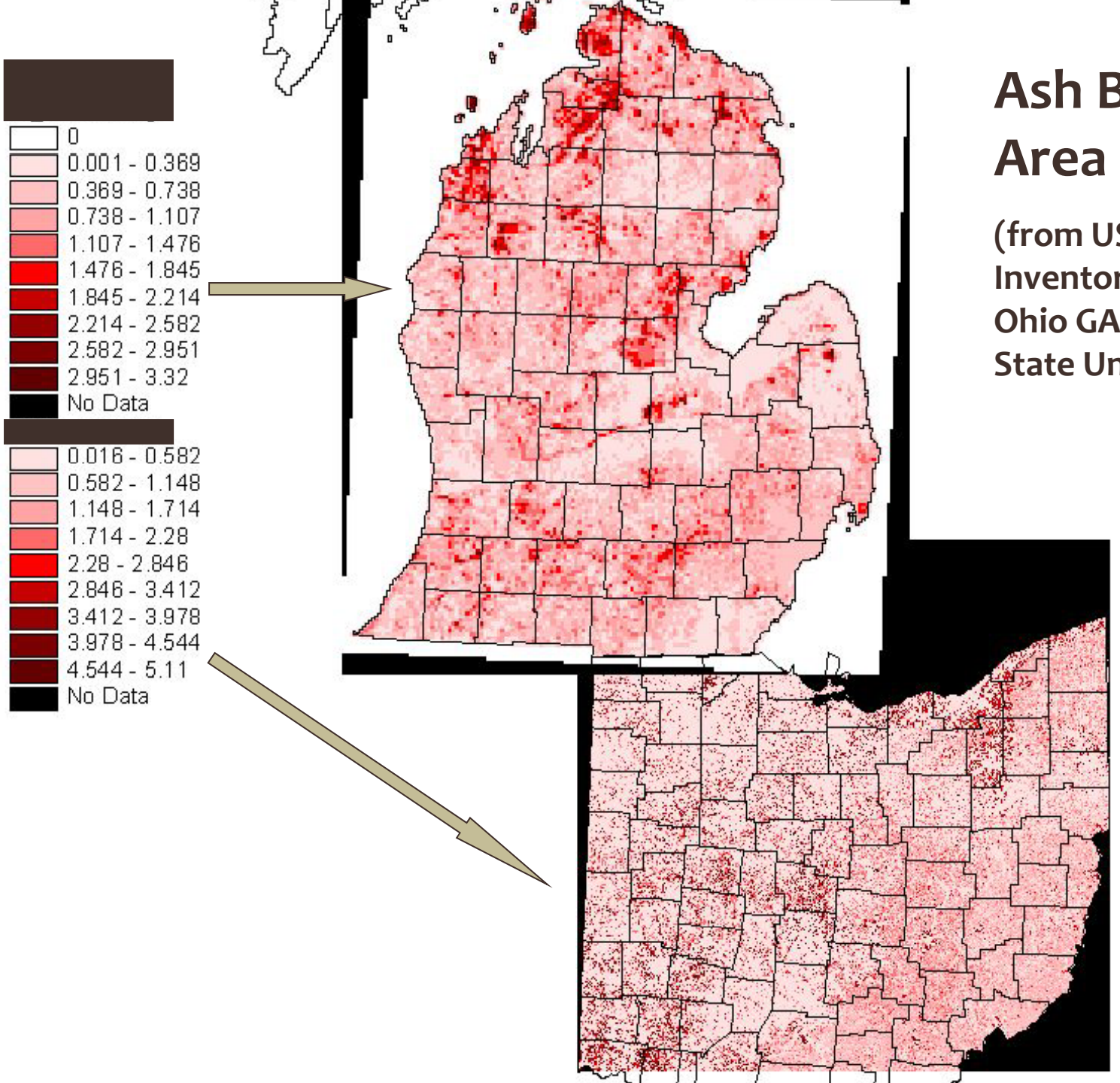
- Our hybrid cellular approach takes habitat fragmentation into account and, therefore incorporates spatial structure

- We specifically take into account stochasticity, and anthropogenic factors that influence the spread of EAB in a spatially explicit cellular framework

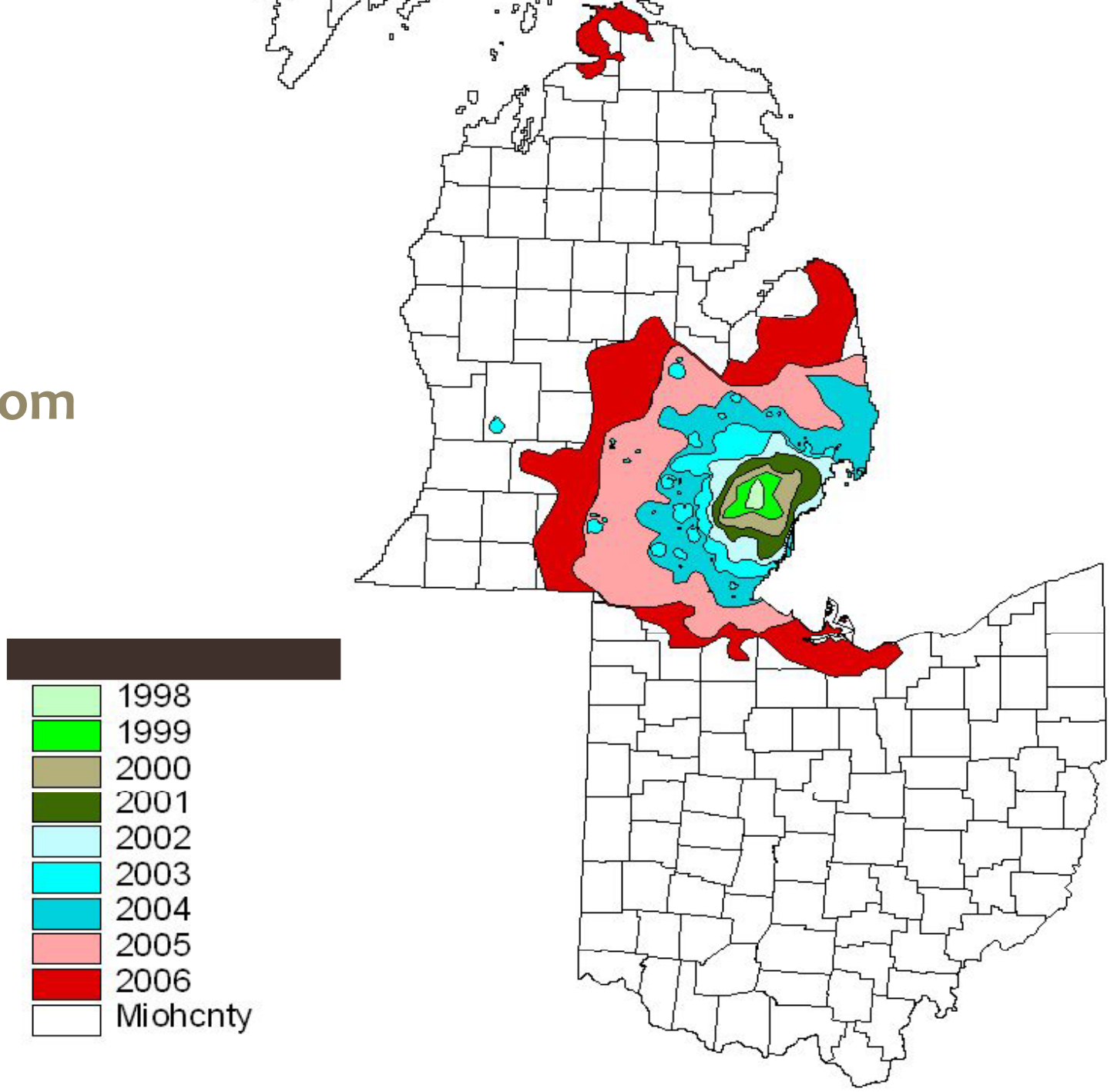

Available Ash
110°W
105°W
100°W
95°W
90°W
85°W
80°W
75°W
70°W
65°W
60°N
45°N
40°N
35°N
30°N
25°N
Available Ash
1000 sq ft basal area
1 - 100
100 - 200
200 - 500
500 - 1000
1000 - 2000
2000 - 3600
Cooperative Emerald Ash Borer Project
EAB locations in Illinois, Indiana, Kentucky, Maryland, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Virginia, Wisconsin, West Virginia and Canada
April 1, 2010
Minnesota
Wisconsin
Michigan
Ontario
Quebec
New York
Pennsylvania
Ohio
Illinois
Indiana
Missouri
West Virginia
Virginia
Kentucky
Map Key
USDA

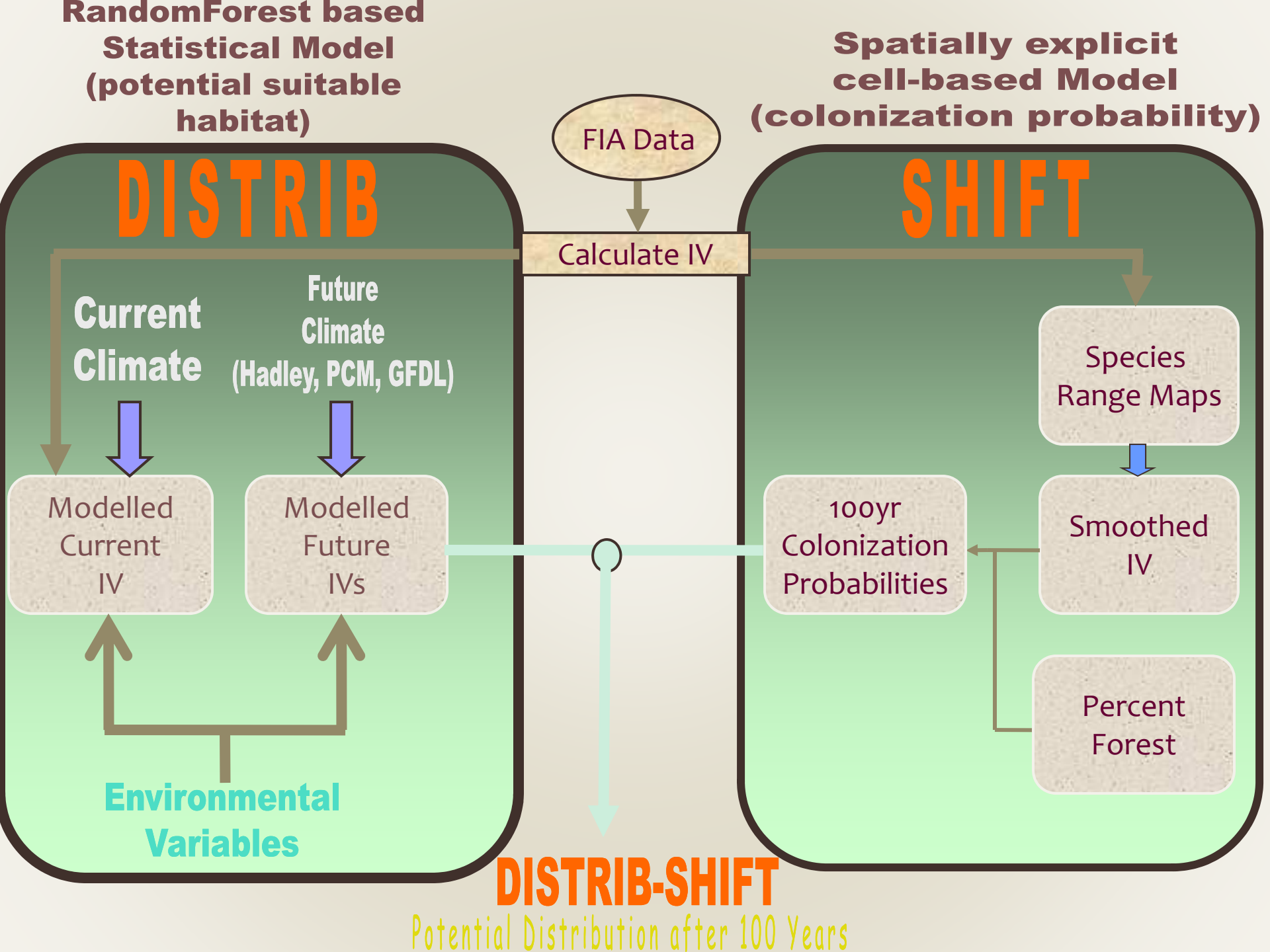
# Ash Basal Area ($m^2/ha$)

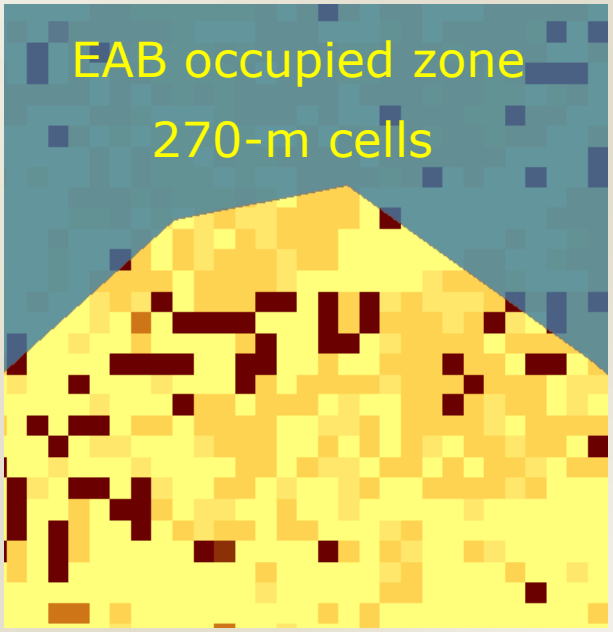
**(from USFS Forest Inventory Analysis, Ohio GAP & Michigan State Univ.)**



# EAB Front from 1998 to 2006




RandomForest based Statistical Model (potential suitable habitat)
Spatially explicit cell-based Model (colonization probability)
FIA Data
DISTRIB
SHIFT
Calculate IV
Current Climate
Future Climate (Hadley, PCM, GFDL)
Species Range Maps
Modelled Current IV
Modelled Future IVs
100yr Colonization Probabilities
Smoothed IV
Percent Forest
Environmental Variables
DISTRIB-SHIFT
Potential Distribution after 100 Years




**Inputs:**
- Habitat Quality (Ash BA)
- EAB Abundance

**Output:**
- Index of Risk (prob. of infest.)

**Cell States:**
- Occupied/Unoccupied
- Ash Quantity, BA

Habitat quality (ash basal area) of unoccupied cell i and occupied cell j

$$P_{colonization,\ i} = HQ_i \left( \Sigma HQ_j \times F_j \times (C/D_{i,j}^{y}) \right)$$

colonization constant – used to calibrate infestation rate of approx. 20 km/yr

EAB abundance (0-1) multiplier in occupied cell

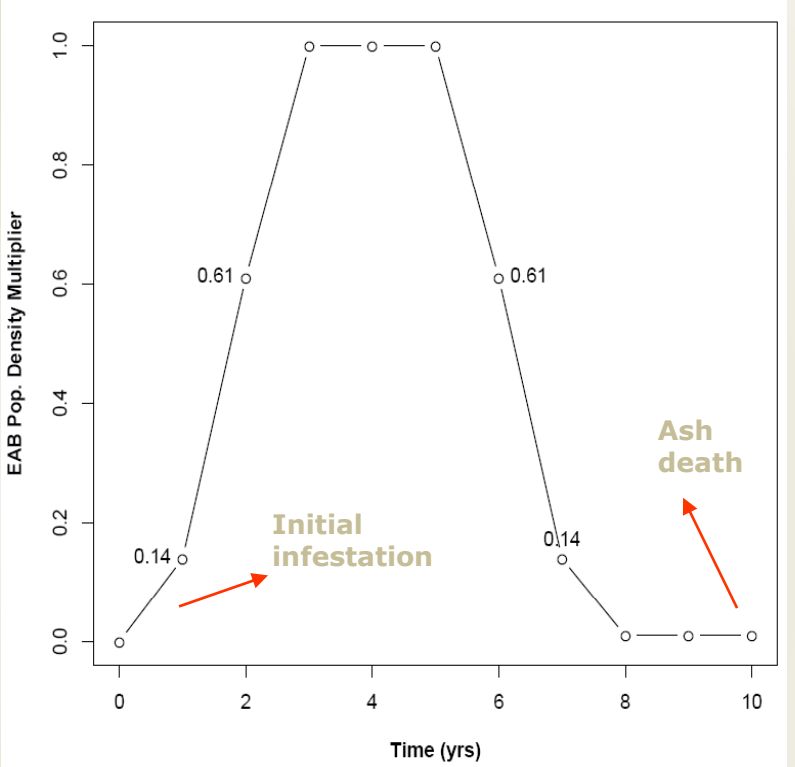
Distance between occupied & unoccupied cells

cumulative probability of unoccupied cell i, becoming infested with EAB

Dispersal exponent, determines the rate of decline with distance

- Update EAB abundance and infestation probability each year (one generation) based on an assumption of an 10-year cycle between initial infestation and complete death of ash
- Once infested, the cell starts a 10 year EAB cycle until ash dies out
- The infestation probability (0-1) for each unoccupied cell is summed across all occupied cells within the search window at each generation. If cell gets > 1, it is considered infested
- For cells with < 1, a random number between 0-1 is chosen and the cell is declared infested if that number is > than the cell sum, adding an element of stochasticity
- These newly infested cells contribute to the infestation prob. of unoccupied cells in the next generation

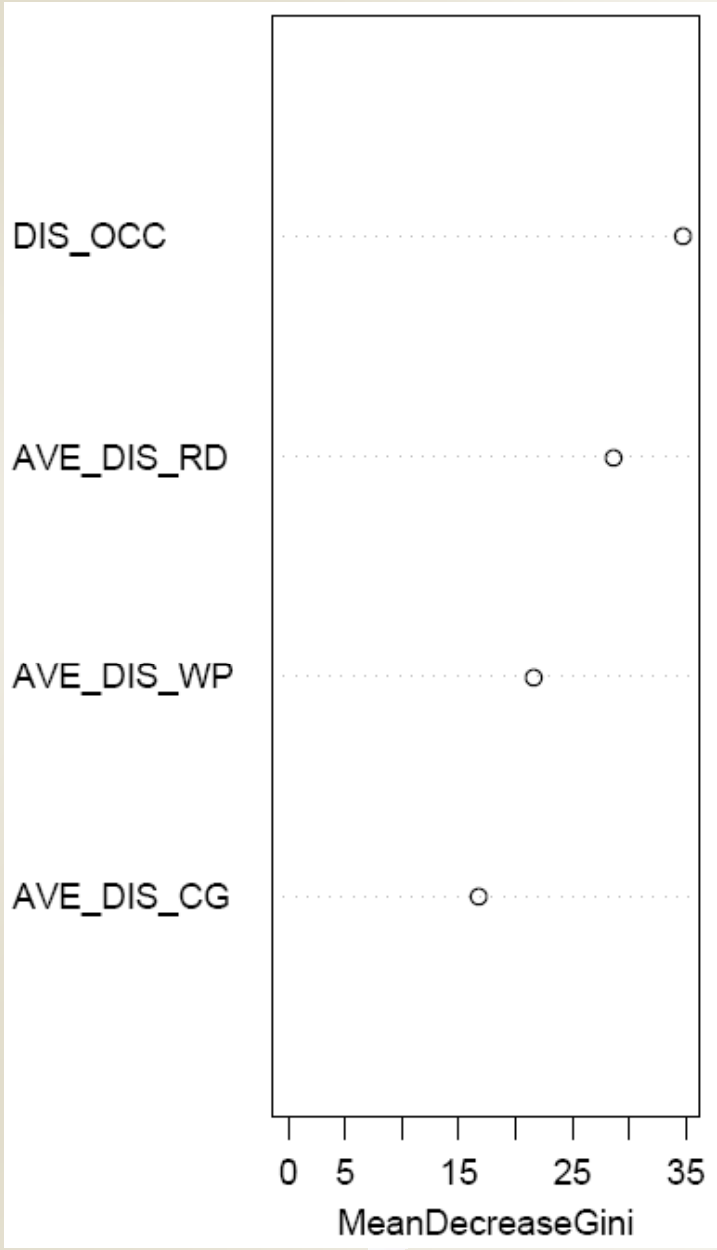
## Updating EAB abundance

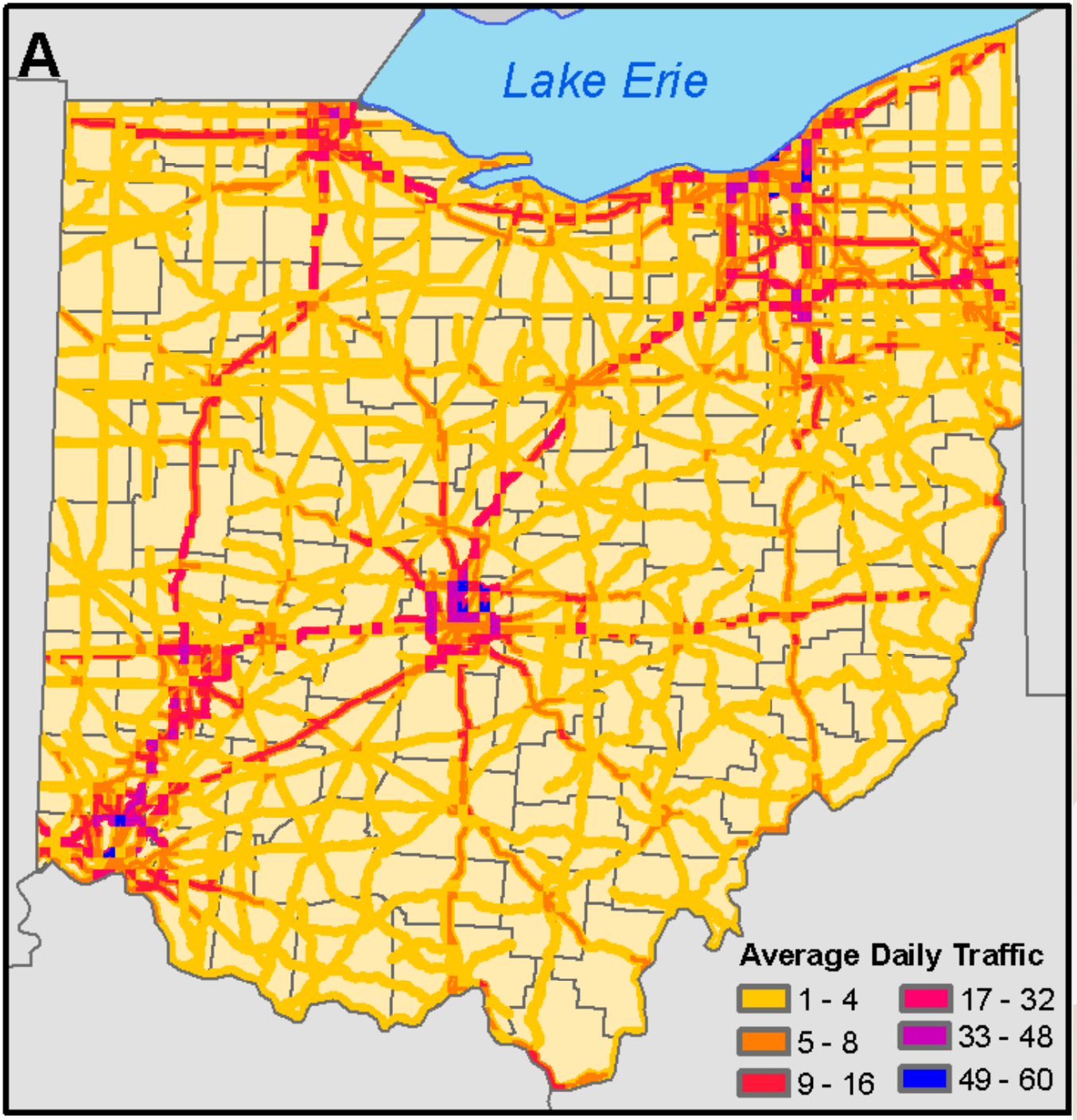



$$P_{colonization,\,i} = HQ_i \left( \Sigma\, HQ_j \times F_j \times (C/D_{i,j}^{y}) \right)$$

# Insect ride weighting scheme

- Get average distance to roads, wood products, campgrounds and occupied (core area) zone from both the EAB positive trees and non-positive detection trees for the outlier (non-core) zone.
- Do a decision-tree based "RandomForest" statistical classification and evaluated the importance of these predictors
- Assess the significance of these factors for insect spread to obtain weighting guidelines.



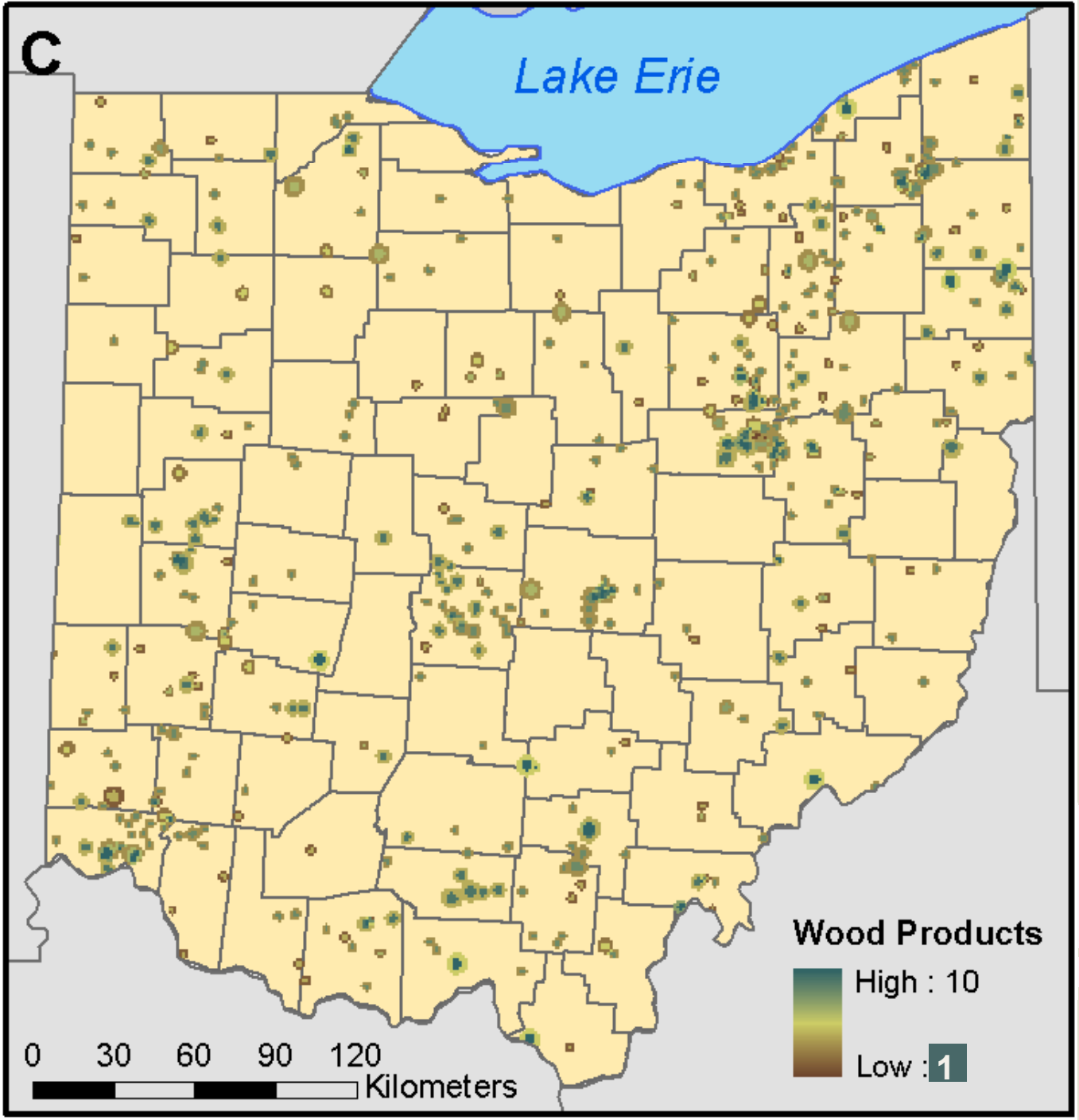



# ROADS

- Analyzed Average Daily Densities (ADT) of Traffic of major roads in Ohio
- ADT values were scaled by buffered distance (1-2km) from each road – max score of 60

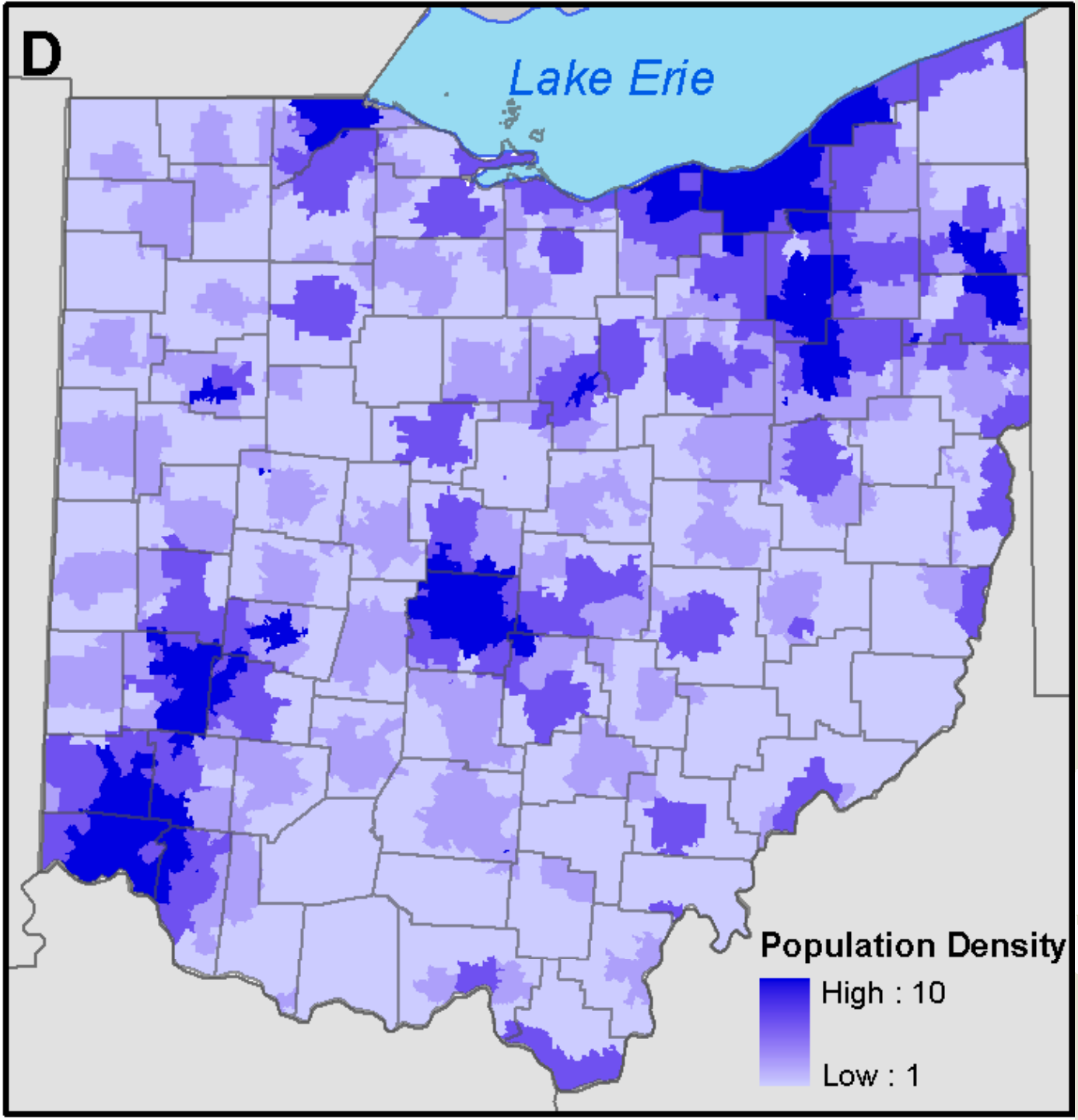
## CAMPGROUNDS

- Gravity model is used to assess people's movement to campgrounds (241) based on the distance and number of sites from EAB infested zip codes.
- We scaled the gravity model's weights by buffering the campgrounds (0-4km) based on the number of campsites – max weight of 20




## WOOD PRODUCT INDUSTRIES

- Assessed industries based on the amount and status of ash used and scaled the weights by buffering sites (0-4km) based on the size of the facility.




## POPULATION DENSITY

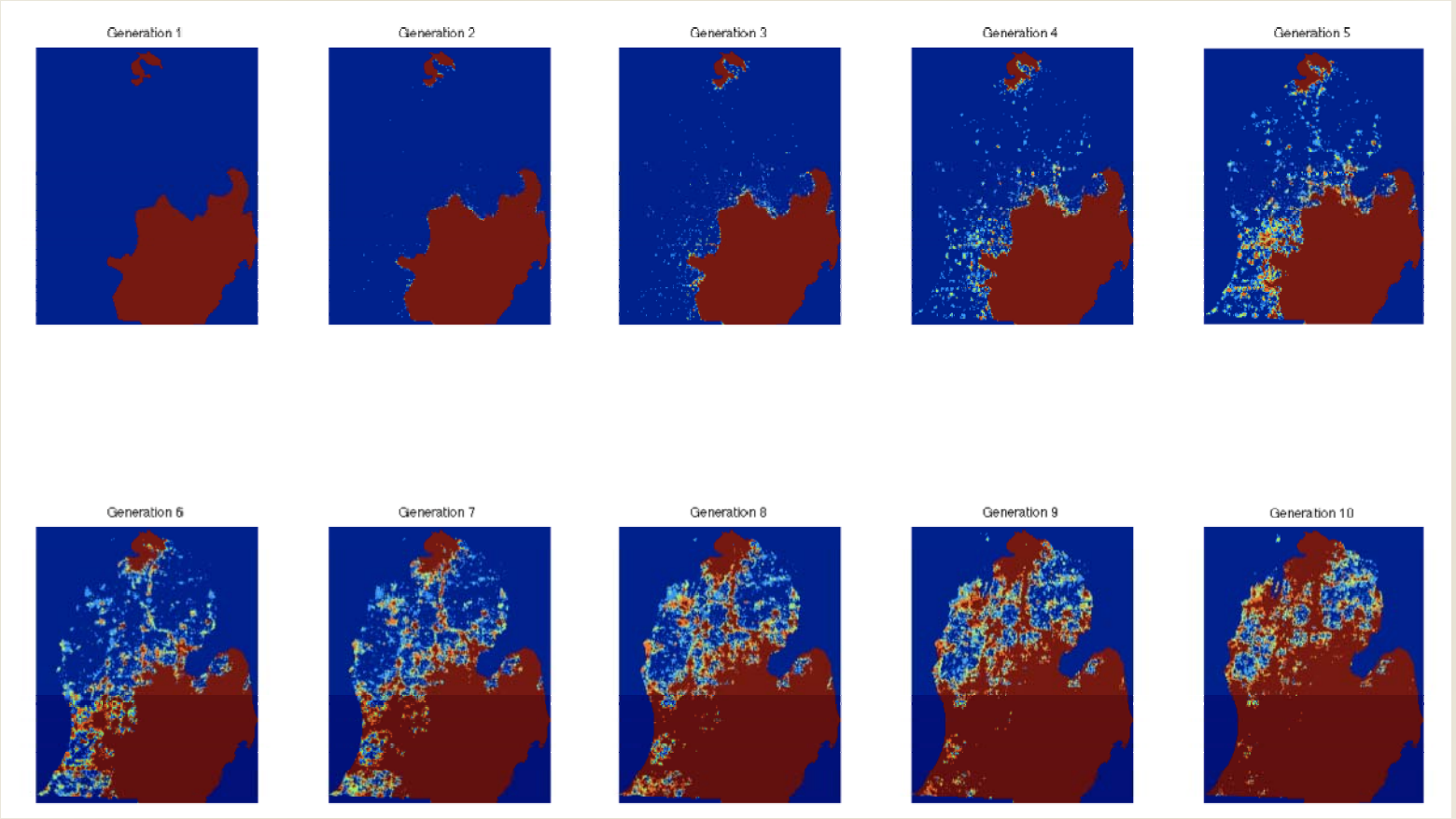
- Although road densities and ADT are good surrogates for pop. density, we used it to capture areas where they do not reflect human assisted movements.

- Max. score of 10

## Quarantined counties in Ohio (in pink)

- Once county is quarantined, ash is legally allowed to be moved only within the county or to any other adjacent quarantined counties.
- We modelled the risk of spread within quarantined counties to be twice that of non-quarantined counties

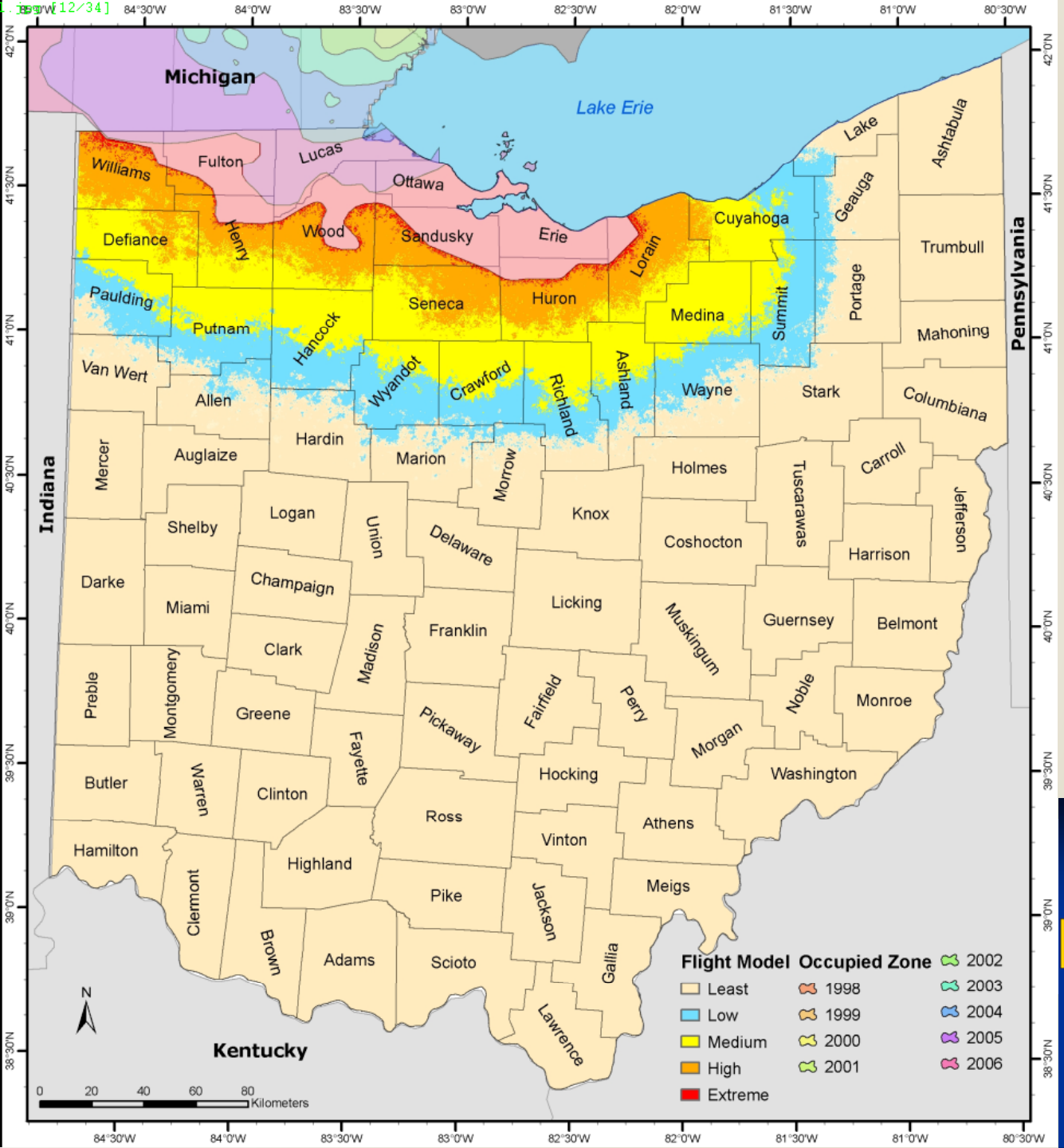
# MI spread for 10 generations

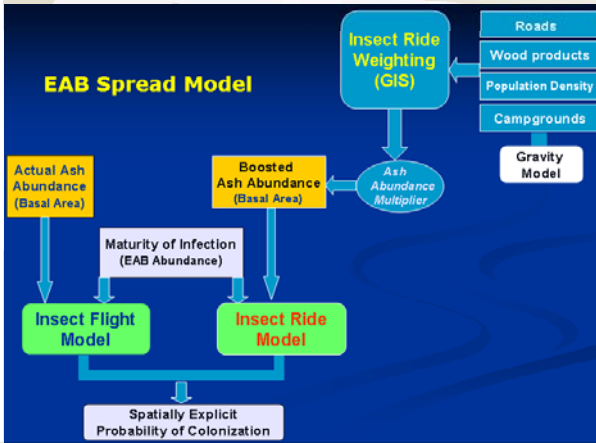



- Simulation results shown ran at Ohio Supercomputing Center

# Insect flight model

## 40 km search window

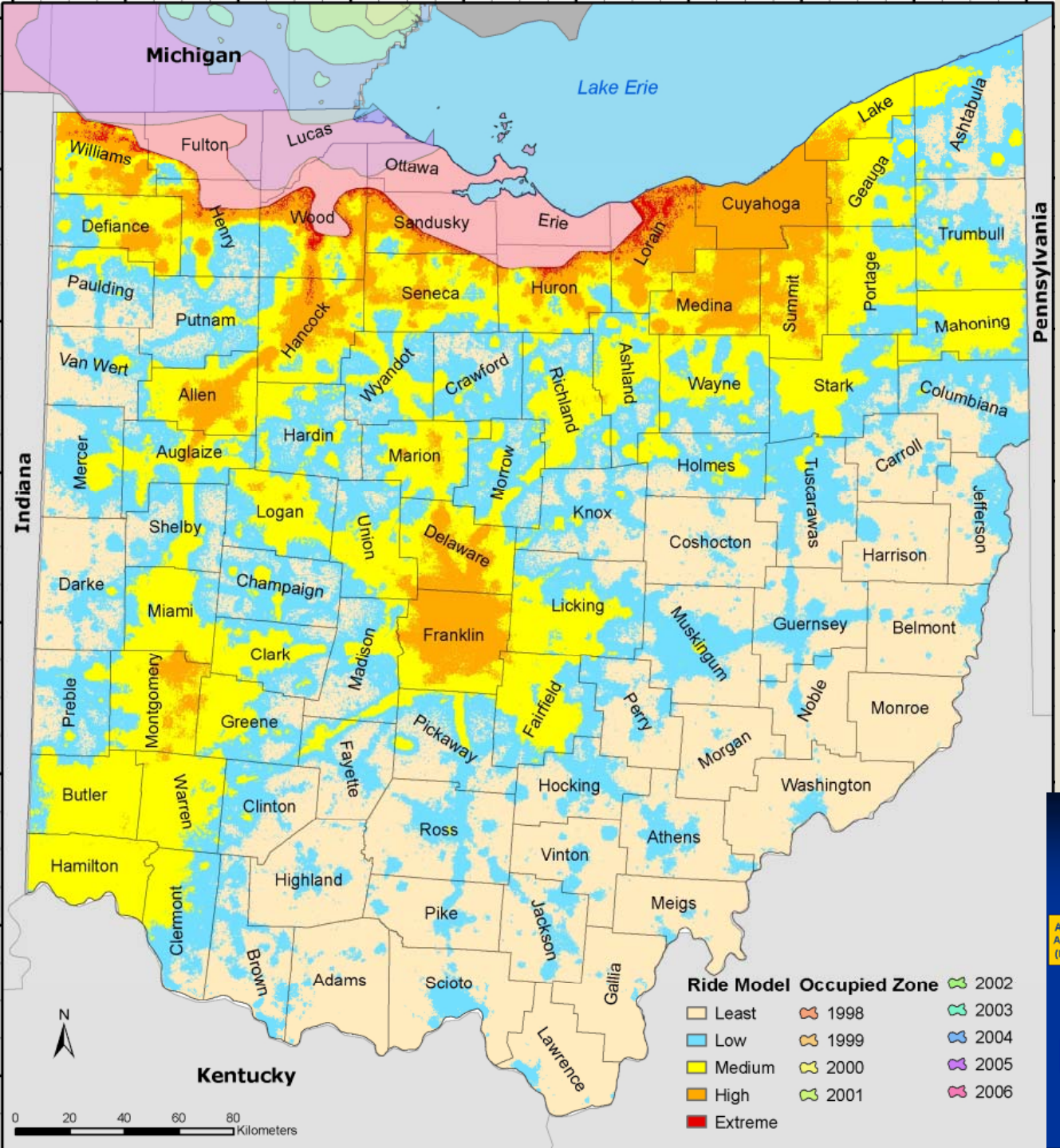


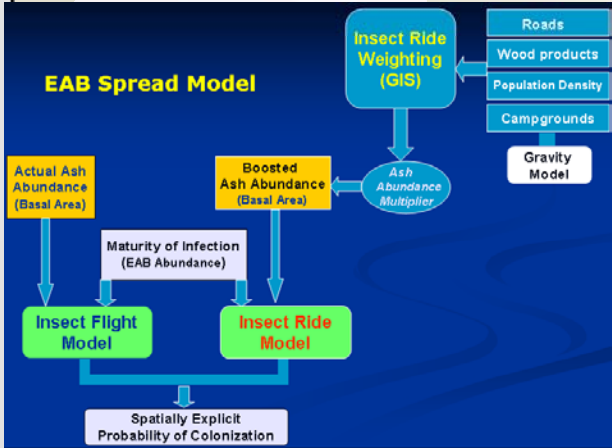



# Insect ride model

## 400 km search window

**Estimates Risk of Spread away from the "core " of occupied zone**

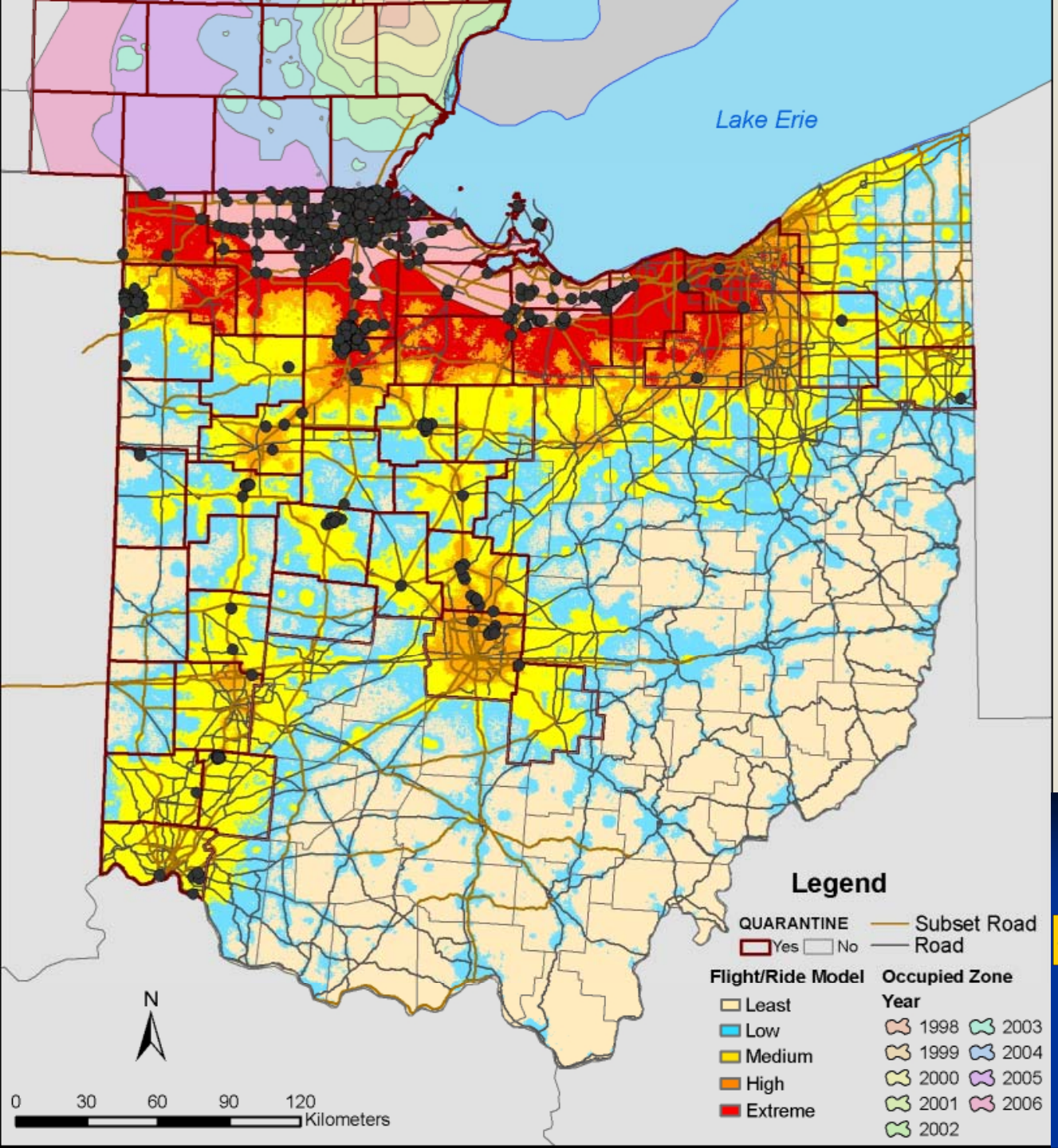


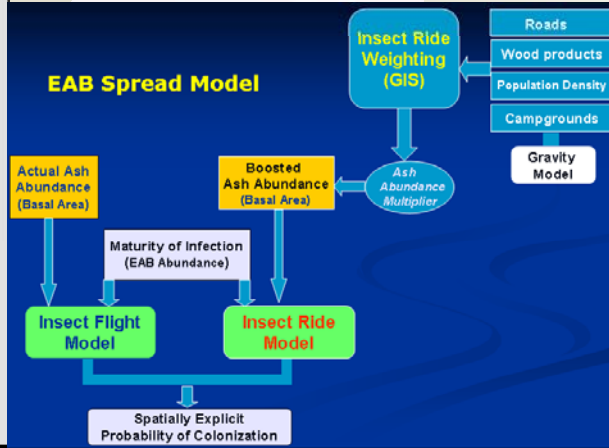



# Combined flight + ride risk map

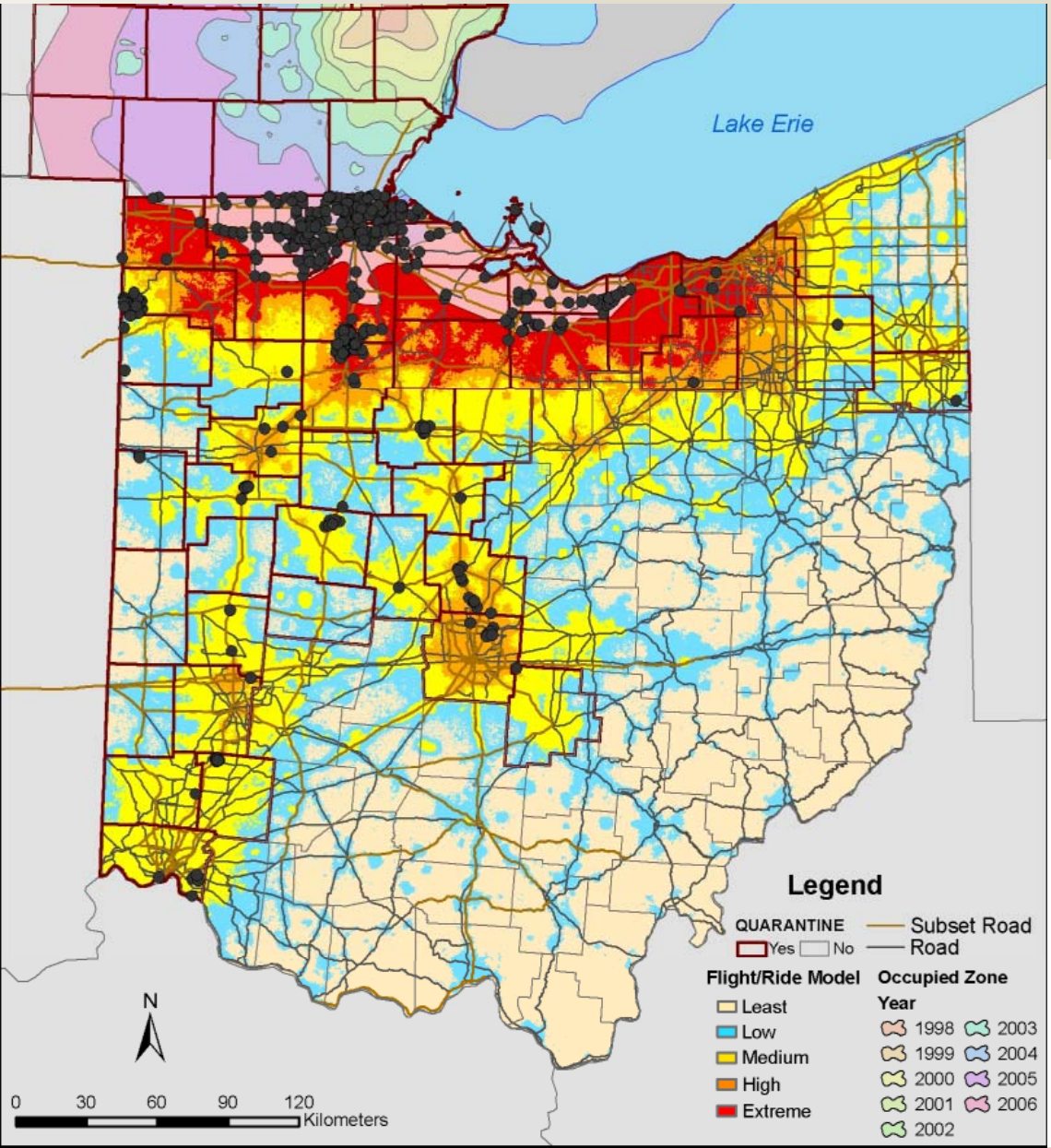
+

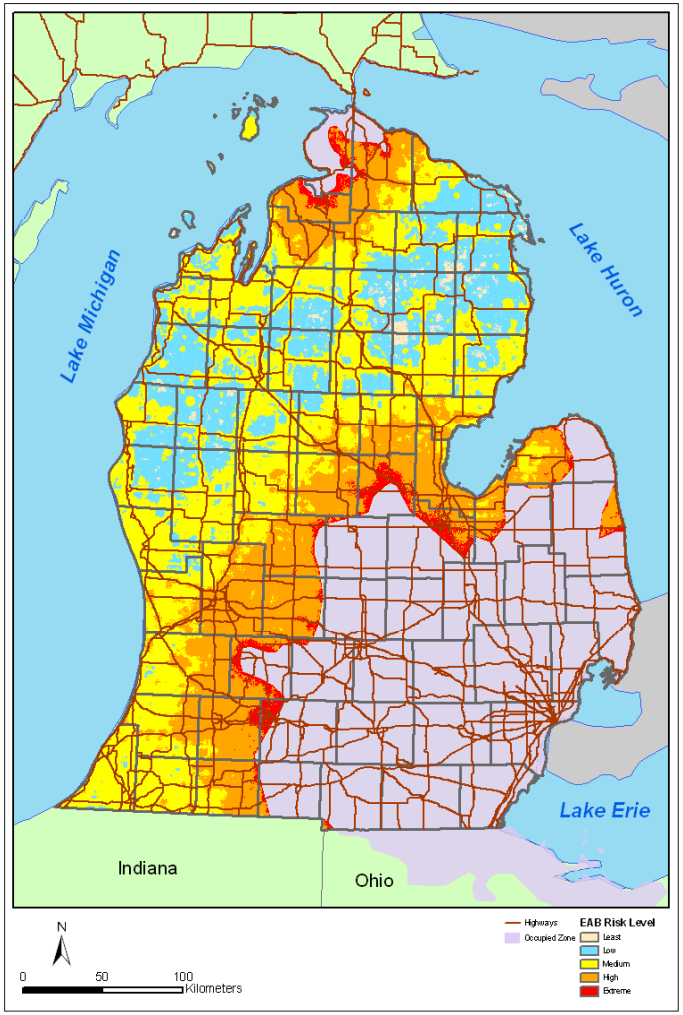
# EAB positives



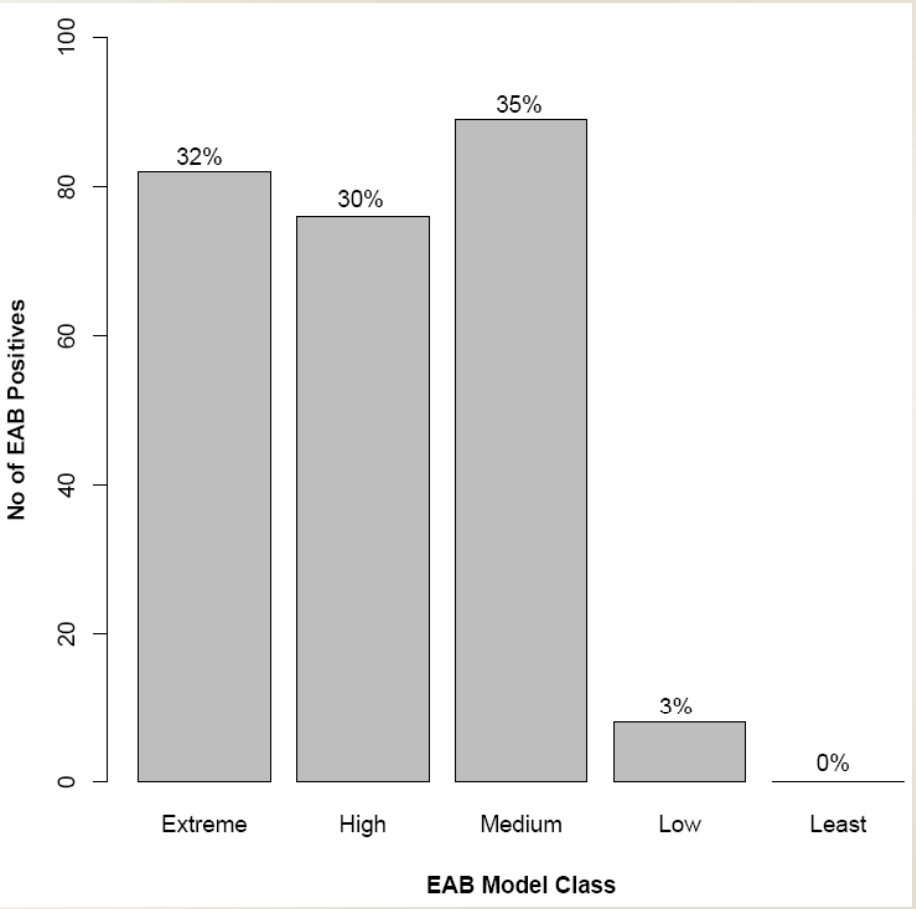



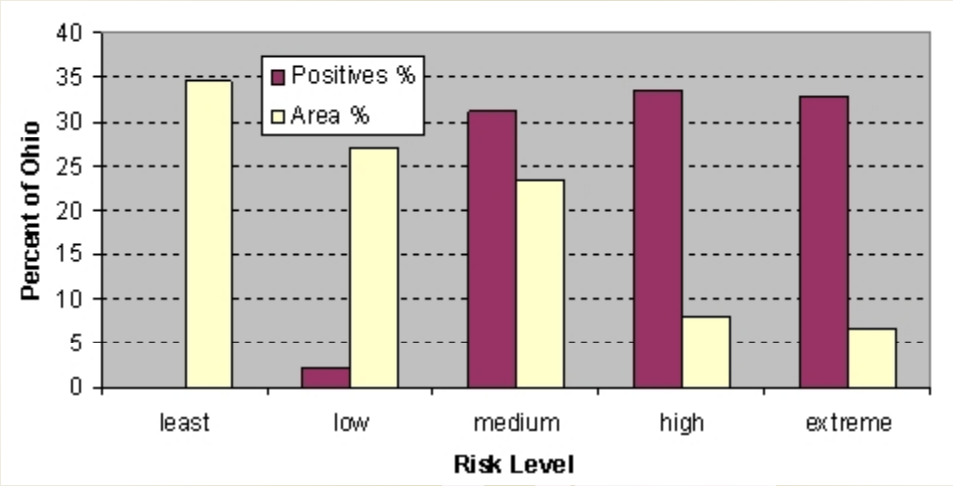
# Combined Flight + Ride Risk Map



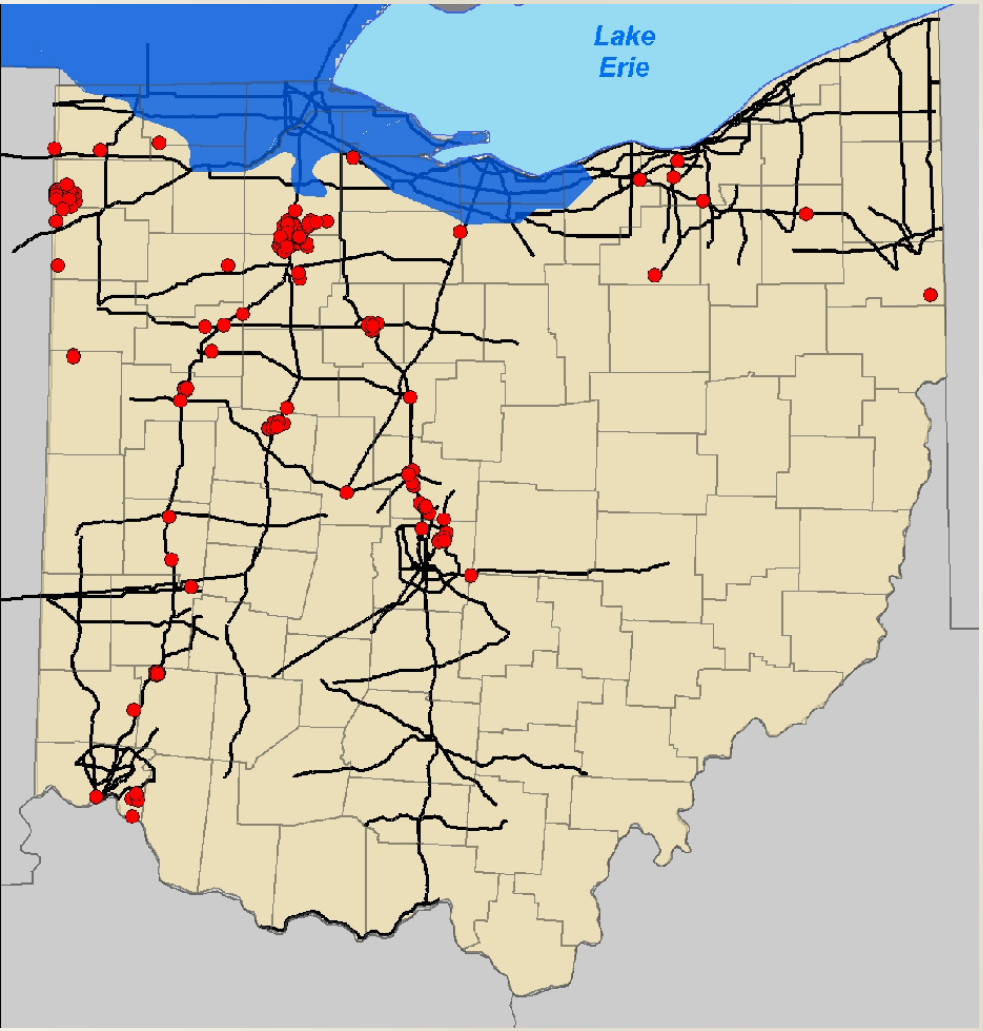
# Promising Aspects of Model Results (not validation!)

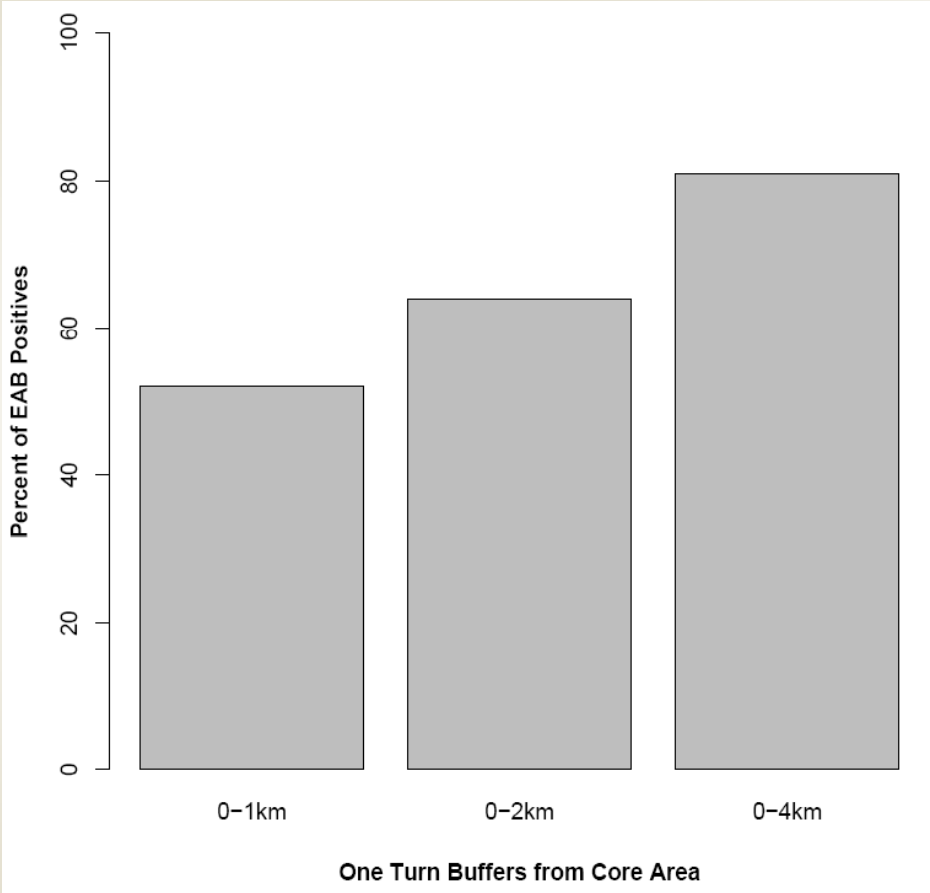



**62% of positives in Extreme & Hi class cover only 14% of the state**

# Importance of Road Network




**Subset of Roads represent only 35% of total road length used in modeling**

# Validation vs. Utility

- Aspects of our model results are artifacts of our "EAB-positive-location" influenced weighting scheme - problematic to validate.

- However, we used a robust statistical technique, RF to test the importance & give insights for weighting the ride model.

- Created an imputed map of risk in Ohio based just on the RF model and compared it to EAB-SHIFT – shows that our "2-components model" is better than a robust statistical model for predicting EAB positives.

- We hope that our model is of practical use to on-the-ground folks trying to deal with this menace based on uncertain information.

- Our model helps locate areas of high risk and allow managers to focus on areas where the infestation is most likely to occur.

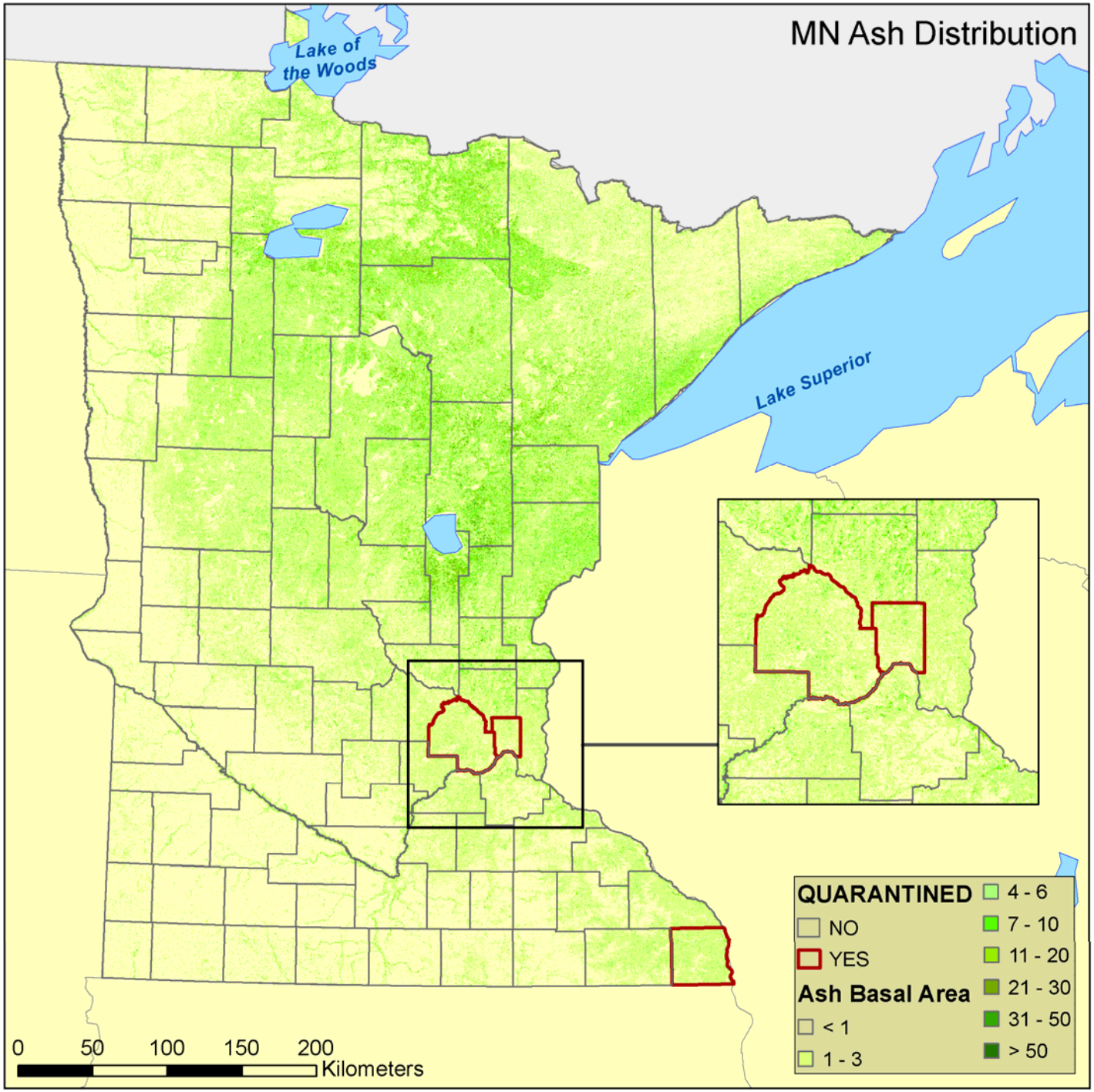
- May give state/county agencies some basis to decide where to locate traps or detection trees.

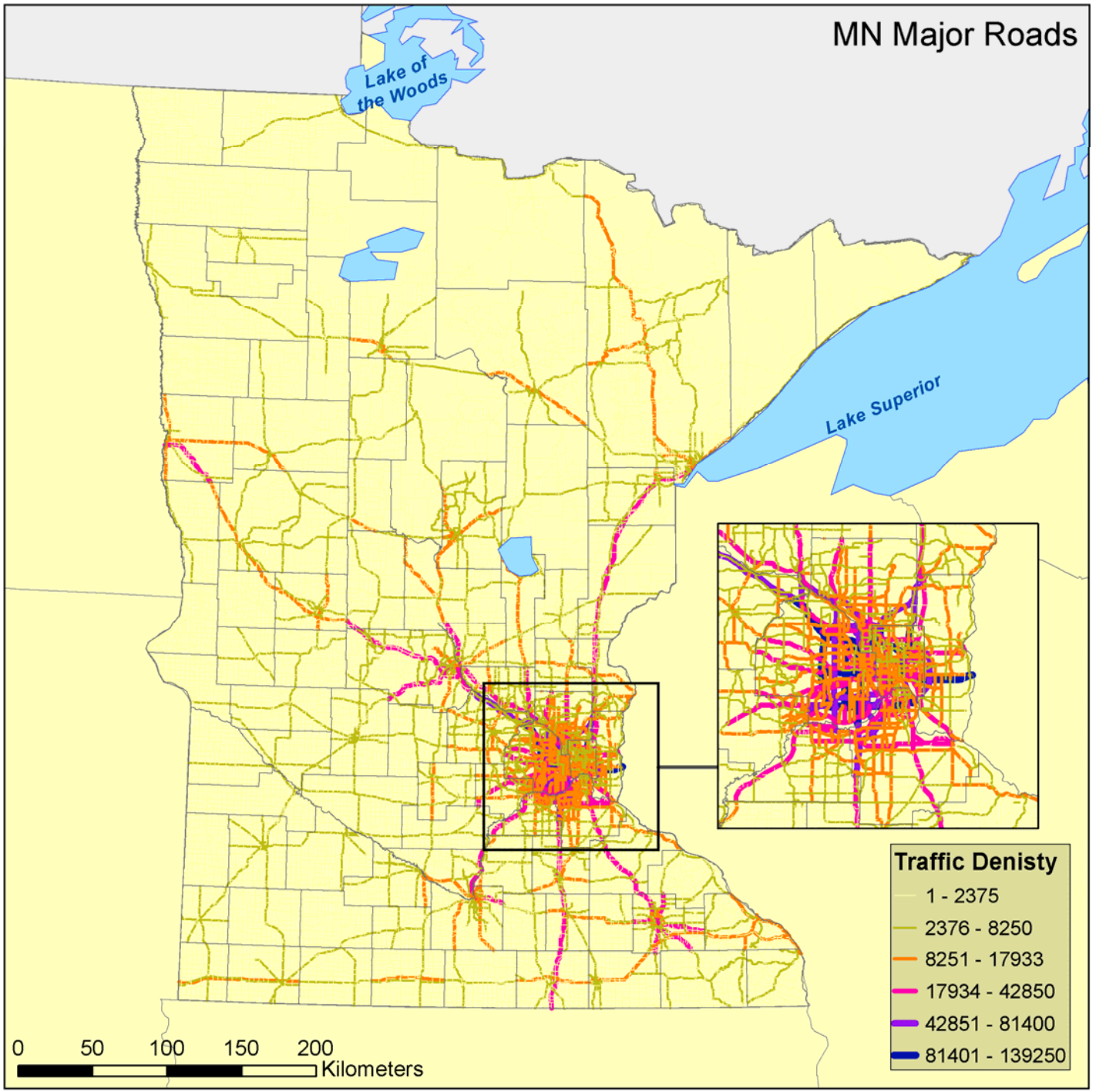
- Could help researchers in sample design.

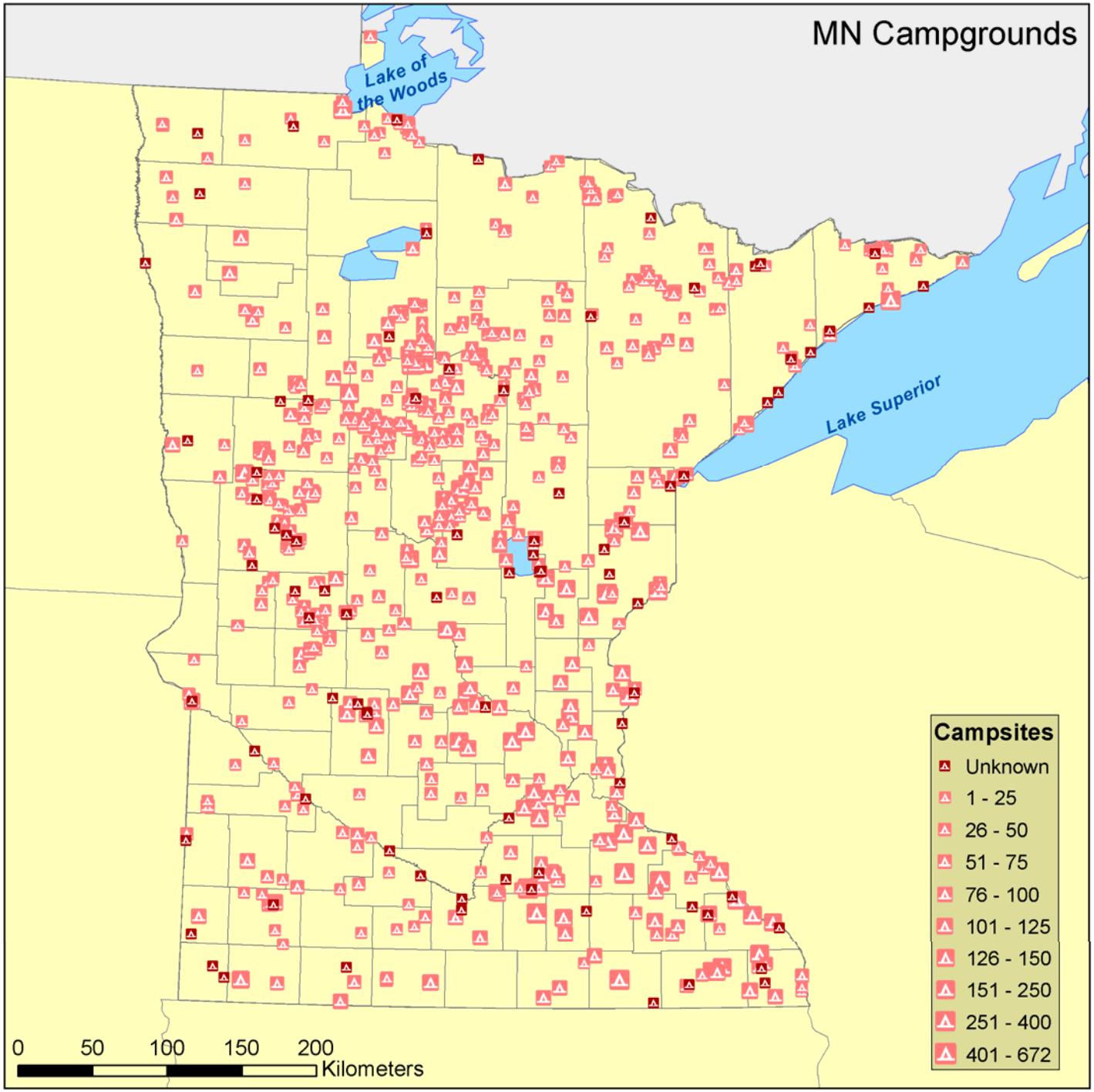
- Will validate/un-validate itself over the years as EAB inevitably spreads across the U.S!

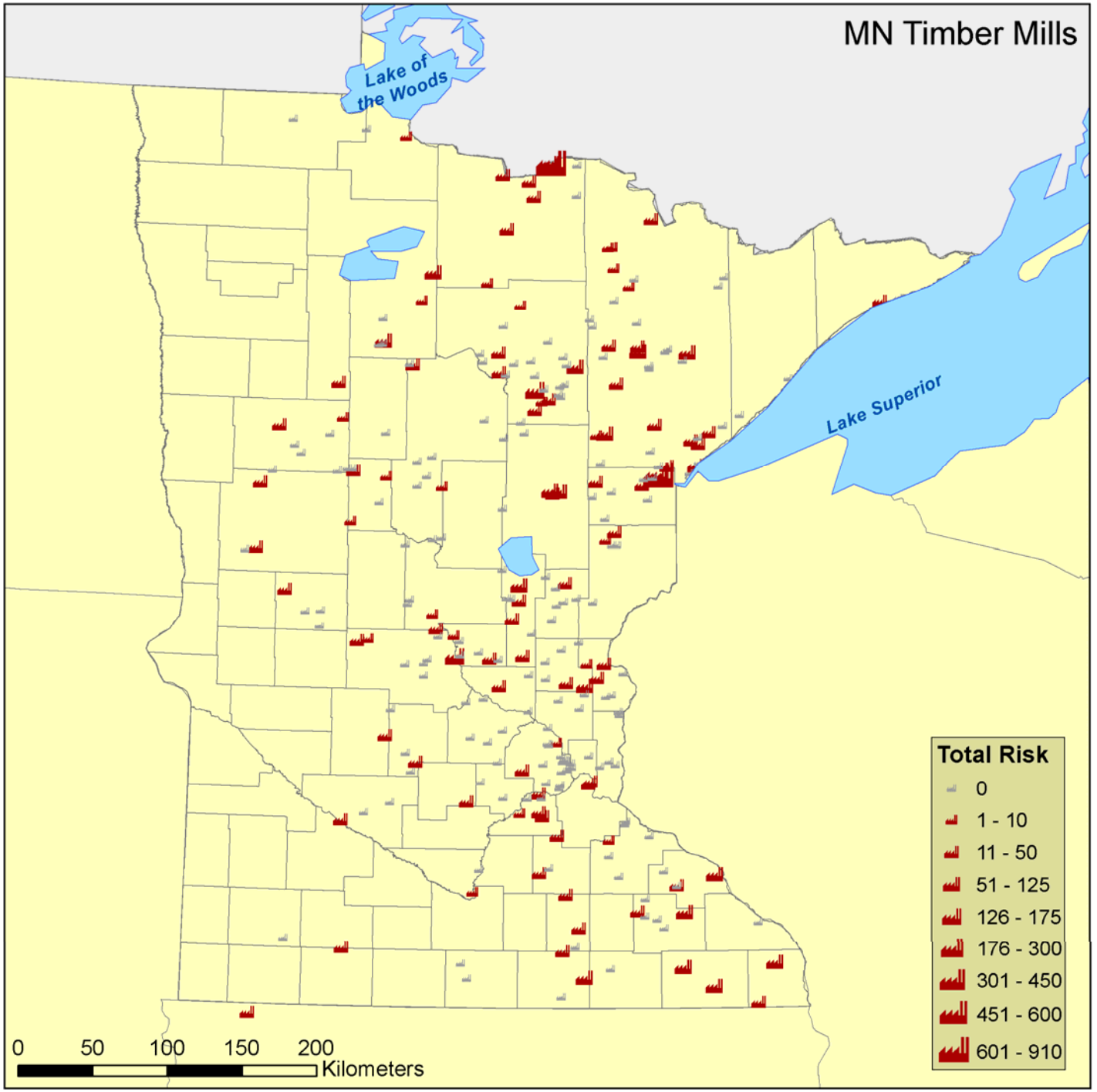
# Model building for Minnesota

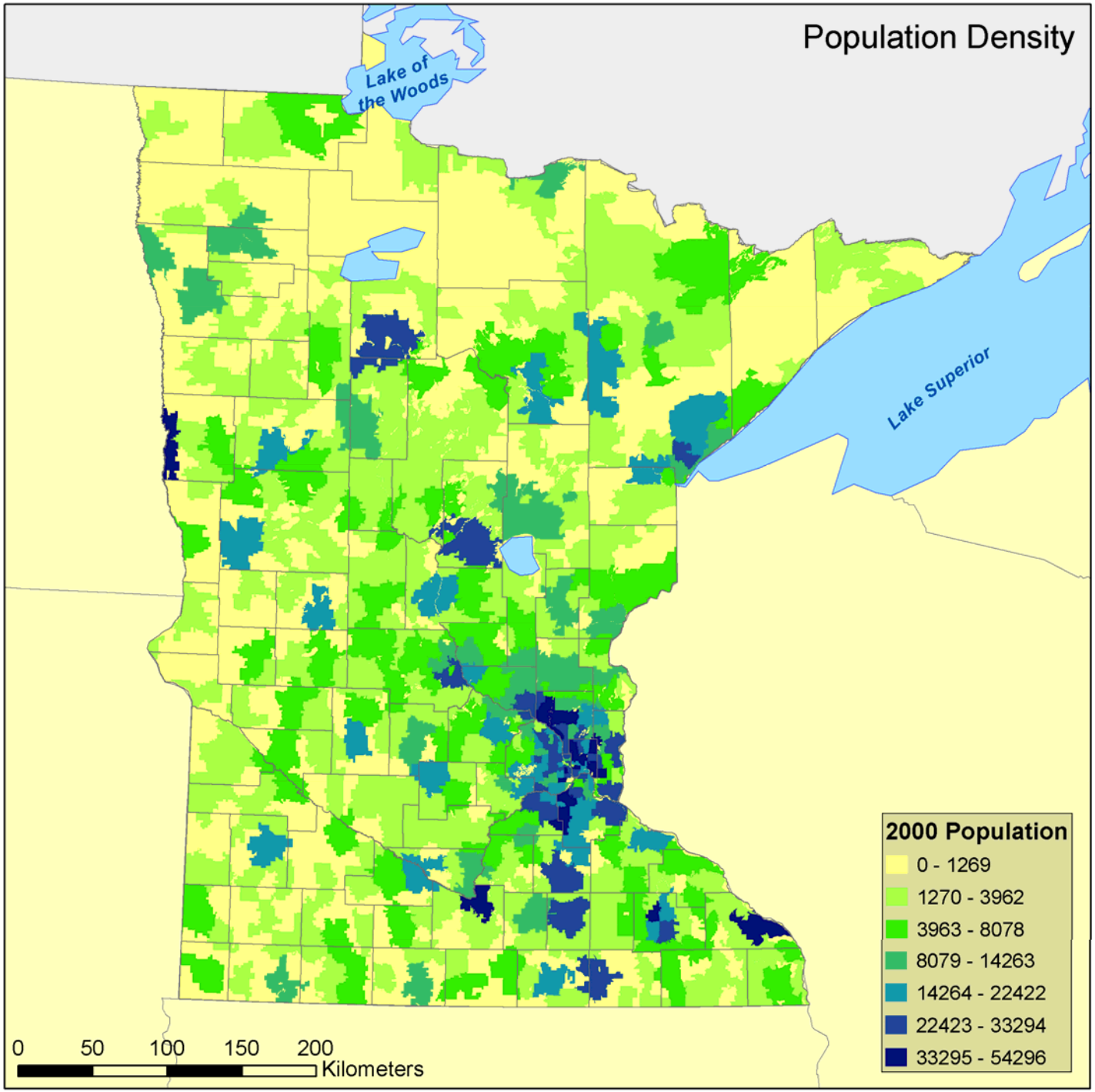
- Input data generated by Minnesota DNR, primarily Dennis Kepler
- We plan to run the model this summer
- The following slides display some of the data

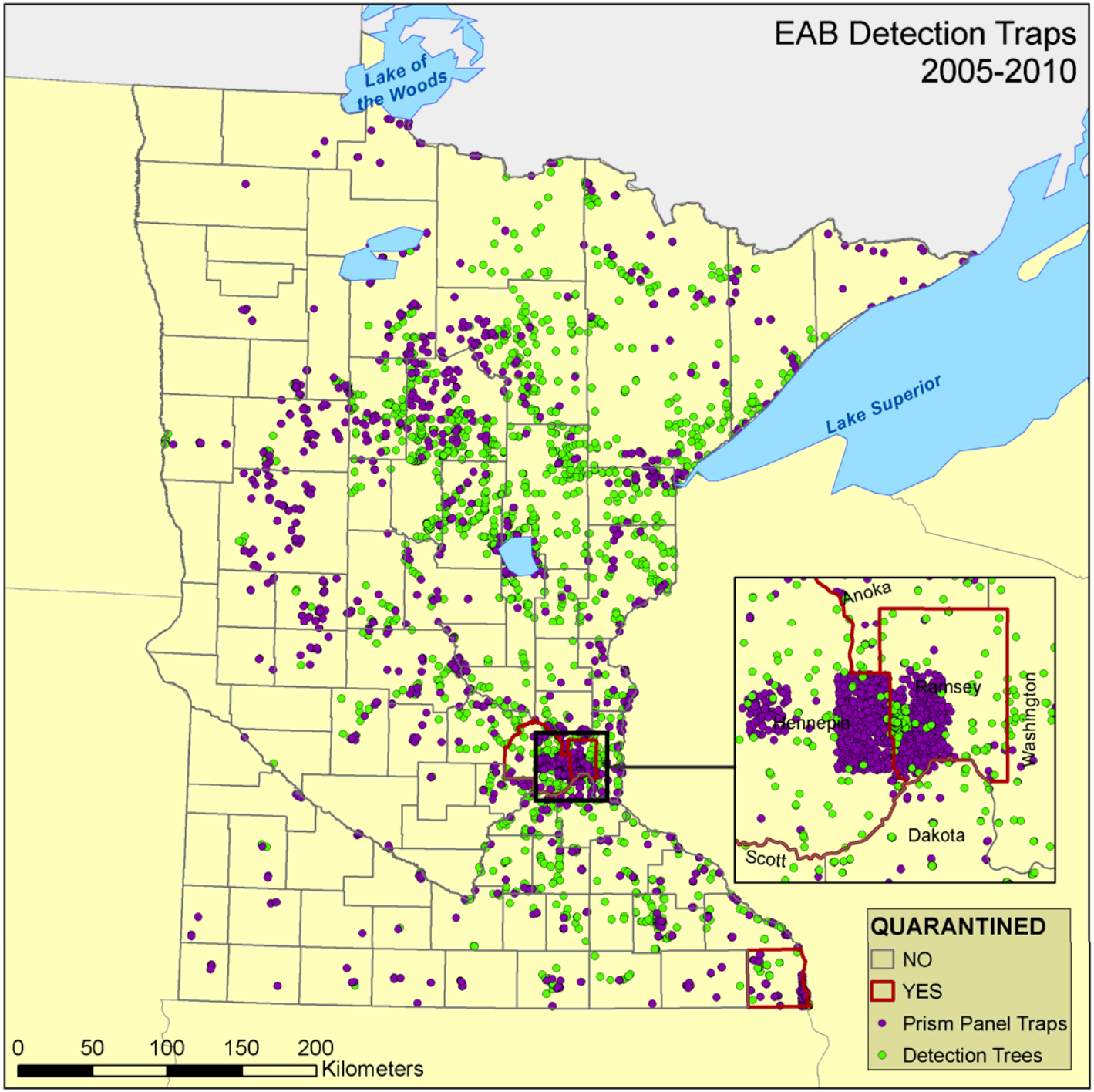

MN Ash Distribution
Lake of the Woods
Lake Superior
QUARANTINED
NO
YES
Ash Basal Area
< 1
1 - 3
4 - 6
7 - 10
11 - 20
21 - 30
31 - 50
> 50
0
50
100
150
200
Kilometers

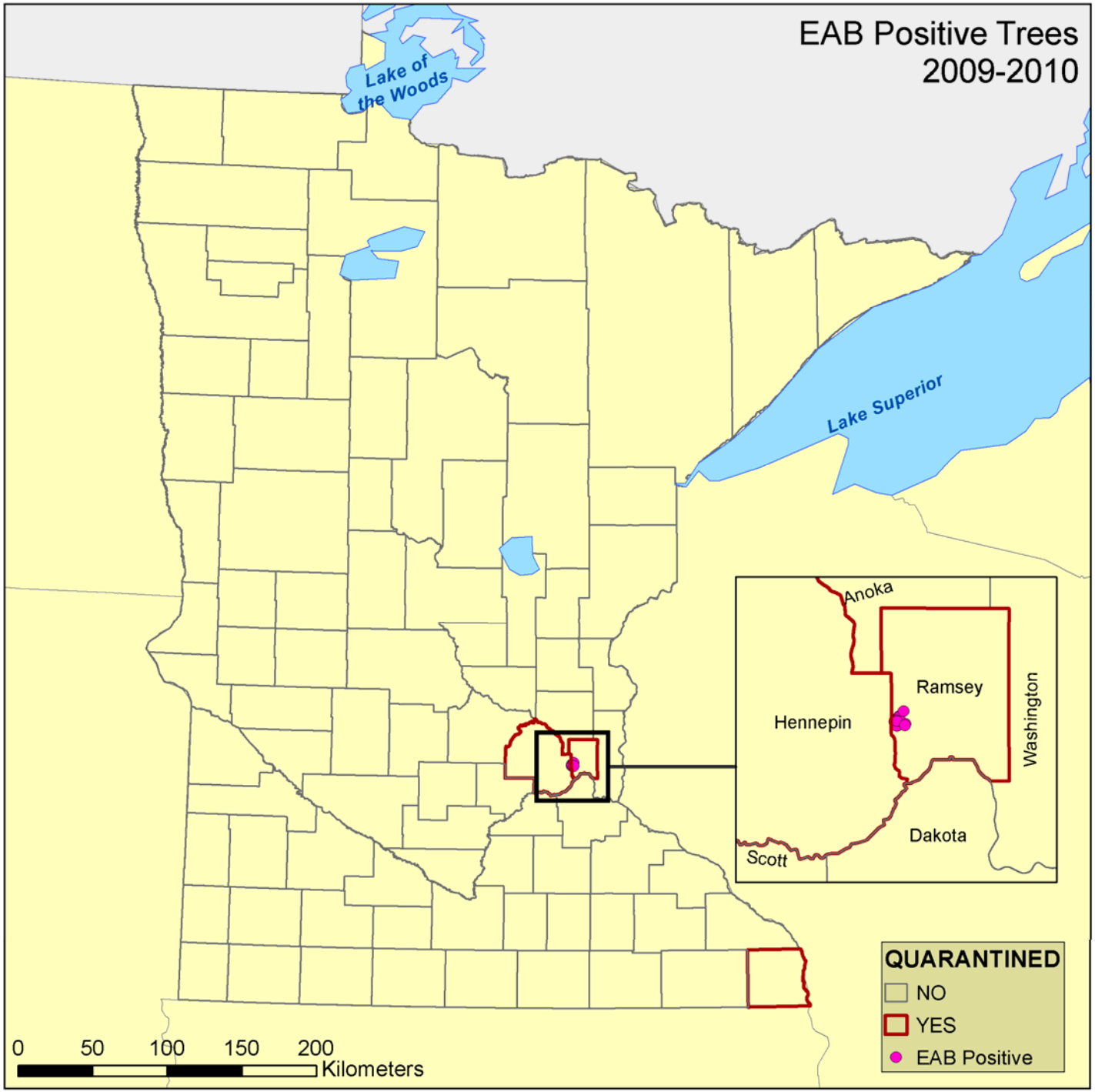

MN Major Roads
Lake of the Woods
Lake Superior
Traffic Denisty
1 - 2375
2376 - 8250
8251 - 17933
17934 - 42850
42851 - 81400
81401 - 139250
0
50
100
150
200
Kilometers

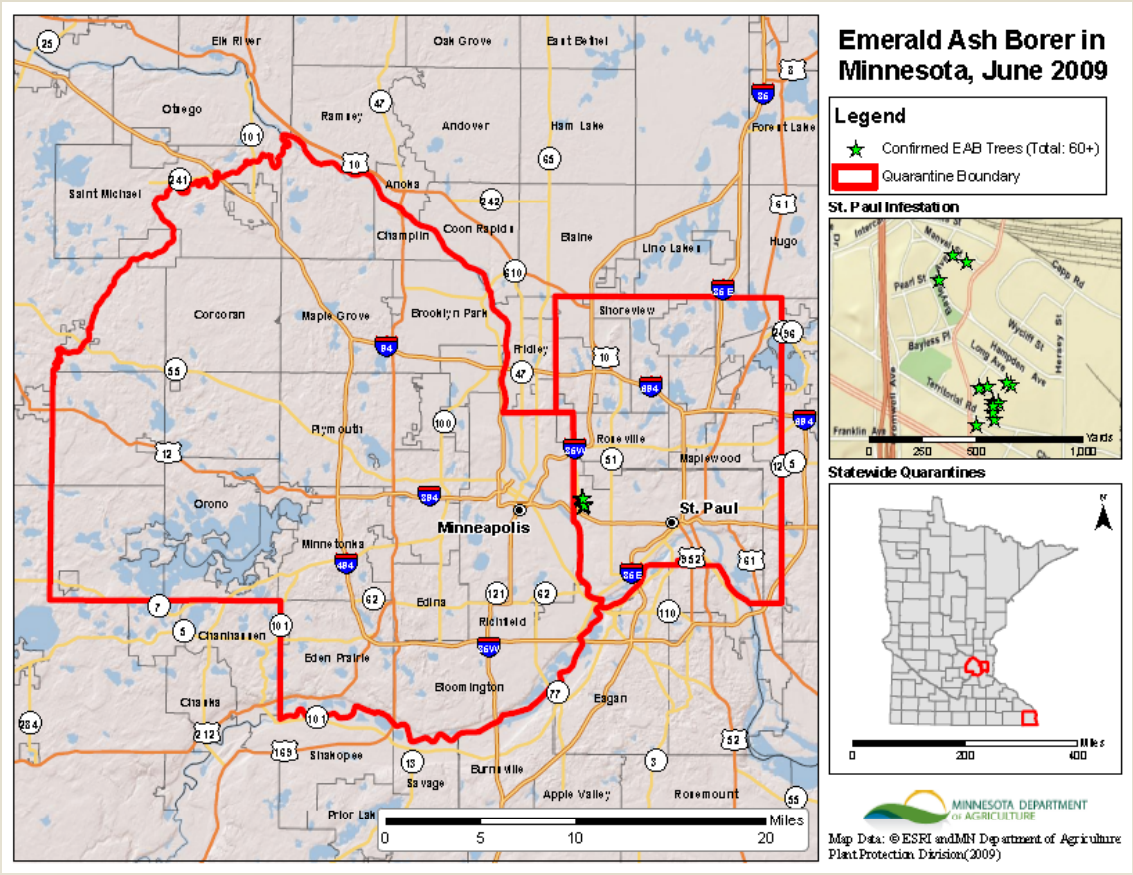

MN Campgrounds
Lake of the Woods
Lake Superior
Campsites
Unknown
1 - 25
26 - 50
51 - 75
76 - 100
101 - 125
126 - 150
151 - 250
251 - 400
401 - 672
0
50
100
150
200
Kilometers

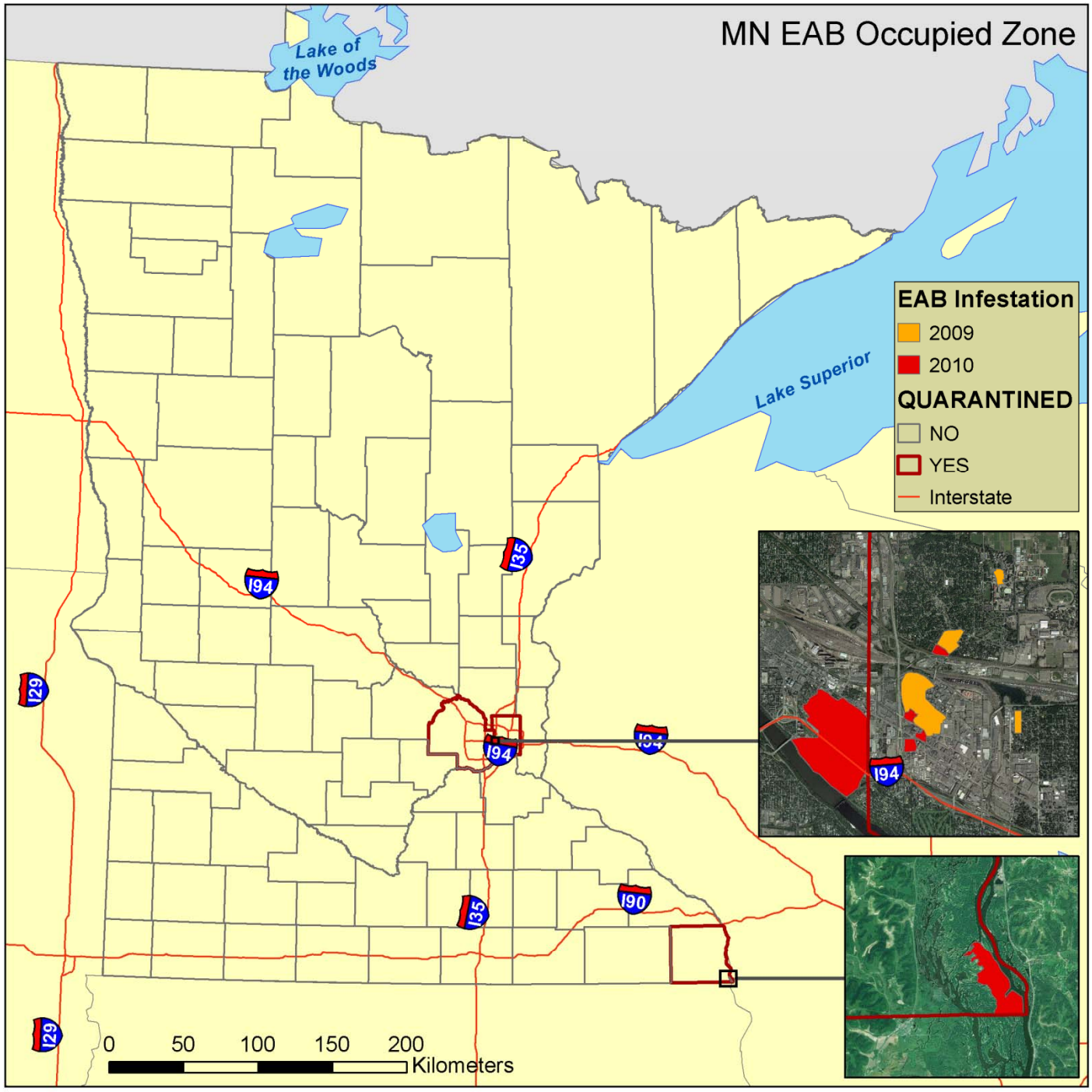

MN Timber Mills
Lake of the Woods
Lake Superior
Total Risk
0
1 - 10
11 - 50
51 - 125
126 - 175
176 - 300
301 - 450
451 - 600
601 - 910
0
50
100
150
200
Kilometers


Population Density
Lake of the Woods
Lake Superior
2000 Population
0 - 1269
1270 - 3962
3963 - 8078
8079 - 14263
14264 - 22422
22423 - 33294
33295 - 54296
0
50
100
150
200
Kilometers


EAB Detection Traps
2005-2010
Lake of the Woods
Lake Superior
Anoka
Ramsey
Hennepin
Washington
Dakota
Scott
QUARANTINED
NO
YES
Prism Panel Traps
Detection Trees
0
50
100
150
200
Kilometers


EAB Positive Trees
2009-2010
Lake of the Woods
Lake Superior
Anoka
Ramsey
Hennepin
Washington
Dakota
Scott
0 50 100 150 200
Kilometers
QUARANTINED
NO
YES
EAB Positive


Emerald Ash Borer in Minnesota, June 2009
Legend
Confirmed EAB Trees (Total: 60+)
Quarantine Boundary
St. Paul Infestation
Statewide Quarantines
Minneapolis
St. Paul
Elk River
Oak Grove
East Bethel
Otsego
Ramsey
Andover
Ham Lake
Forest Lake
Saint Michael
Anoka
Champlin
Coon Rapids
Blaine
Lino Lakes
Hugo
Corcoran
Maple Grove
Brooklyn Park
Shoreview
Fridley
Plymouth
Roseville
Maplewood
Orono
Minnetonka
Edina
Richfield
Chanhassen
Eden Prairie
Bloomington
Eagan
Chaska
Shakopee
Savage
Burnsville
Apple Valley
Rosemount
Prior Lake
Miles
0
5
10
20
Yards
0
250
500
1,000
Miles
0
200
400
MINNESOTA DEPARTMENT OF AGRICULTURE
Map Data: © ESRI and MN Department of Agriculture Plant Protection Division (2009)


MN EAB Occupied Zone
Lake of the Woods
Lake Superior
EAB Infestation
2009
2010
QUARANTINED
NO
YES
Interstate
I94
I35
I90
I29
0
50
100
150
200
Kilometers

We welcome your ideas & suggestions!

*Thank you!*

Landscape Ecol (2010) 25:353–369
DOI 10.1007/s10980-009-9434-9

RESEARCH ARTICLE

# Modeling the invasive emerald ash borer risk of spread using a spatially explicit cellular model

Anantha M. Prasad · Louis R. Iverson · Matthew P. Peters · Jonathan M. Bossenbroek · Stephen N. Matthews · T. Davis Sydnor · Mark W. Schwartz